AERONAUTICAL ENGINEERING REVIEW

NOVEMBER 1949

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with Eclipse Engine Controls in Charge of Throttles

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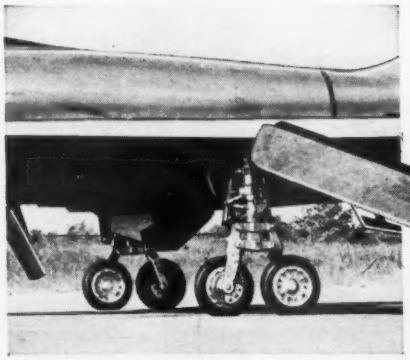

New tandem-type gear replaces standard dual wheel design

Newest way to land a super-jet

HOUSING adequate landing gear within the knife-thin wings of the new, faster, heavier jets is a real engineering problem. In its latest XF-91 jet-rocket fighter, Republic Aircraft solves it by mounting each pair of wheels in tandem (shown in small photo above) and equipping each wheel with a super-compact Goodyear Single Disc Brake. This time-proved brake provides maximum energy absorption in minimum space—*without increasing wheel width!* In addition, it is self-adjusting, self-cooling and non-fading. That is why it is used on so many of the world's aircraft—both private and commercial as well as military. For dependable stopping power, specify Goodyear brakes. To consult our engineers, write: Goodyear, Aviation Products Division, Akron 16, Ohio or Los Angeles 54, California.

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► This is the final rehearsal of a new Wright Cyclone before taking to the air.

► It has already passed through five preliminary stages . . . (1) *green* or first assembly; (2) *green* 5-hour stationary test-run; (3) complete dismantling and cleaning; (4) parts inspection; (5) parts reassembled into "final" engine.

► Now in its final test, sensitive recording instruments *check* and Wright technicians *log* the engine's operations from idle to take-off power. A calibrated wooden test club on the propeller-shaft absorbs power developed and forces cooling air across the engine.

► The hundreds of log-sheet entries include data on every phase of engine performance. Every Wright Cyclone passing the "production engine" test is ready to power *any* commercial or conventional military airplane in the world.

► Another example of the care with which the Wright Aeronautical Corporation produces aircraft engines to provide reliability in the air.

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Aeronautical Corporation • Wood-Ridge, New Jersey

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FIRST IN FLIGHT

AERONAUTICAL ENGINEERING REVIEW

Cover—The Martin XB-51 three-jet bomber.

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Editor
Welman A. Shrader

Technical Advisers
Hugh L. Dryden Robert R. Dexter
S. Paul Johnston

Associate Editor B. H. Jarck
Managing Editor John J. Glennon
News Editor Randolph Hawthorne
Reviews Editor Lyons T. Carr

Manager
Joseph P. Ryan

Manager, Western Region
James L. Straight
7660 Beverly Blvd., Los Angeles 36, Calif.

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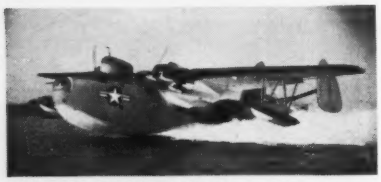
1934—THE CHINA CLIPPER, *first of the big Martin flying boats to fly the Pacific, was the first over-ocean luxury liner, confirmed the practicality of regularly scheduled over-ocean transport flights.*



1937—THE MARINER LINE, *begun in this year, had no peers in World War II as patrol bombers and search planes. And hundreds of Martin Mariners, including PBM-5 shown above, still serve the Navy.*

1948—THE CAROLINE MARS, *world's record-holder for total passengers carried in a single flight, is today's giant descendant of the original "Old Lady" Mars, largest flying boat in the world when it was built in 1942.*

RUGGED NEWCOMER to a Select Circle

WITH its strikingly longer afterbody hull and husky construction, the new Martin XP5M-1 is designed to operate from any of the Earth's open waters 95% of the year! This rugged patrol craft makes safer landings with less pitching and bouncing. Tail surfaces are protected from waves by added buoyancy in the stern. Take-off time and distance are shortened. And the hull is designed to eliminate "skipping off" in landing.

Ideal for patrol work over rough seas, this husky twin-engine plane is expected to have greater range than any other flying boat in its class when completely developed. It's the latest in a great family of Martin flying boats! THE GLENN L. MARTIN COMPANY, BALTIMORE 3, MARYLAND.

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I.A.S. News

A Record of People and Events of Interest to Institute Members

I.A.S. Plans Busy Season of Activities

Three National Meetings Head Events Scheduled for Coming Half Year

THE WRIGHT BROTHERS LECTURE, the Eighteenth Annual Meeting, and the Fifth Annual Flight Propulsion Meeting constitute the principal events on the I.A.S. National Meetings Calendar for 1949 and the first half of 1950. The calendar of local events is also a full one, with Section officers planning far ahead in obtaining notable speakers to address regular gatherings and in arranging field trips to aviation installations in their areas.

▸ **Wright Brothers Lecture.**—On the evening of December 17, in the U.S. Chamber of Commerce Building Auditorium in Washington, D.C., A. E. Russell, Chief Designer (Aircraft), Bristol Aeroplane Company, Ltd., will discuss "Some Factors Affecting Transport Aircraft with Propeller Turbine Engines."

Mr. Russell looks upon propeller turbines as power units that find their most promising use in long-range aircraft, and he will attack the problem of how the greatest possible refinement in design may be achieved in order to obtain maximum efficiency. Modes of vibration, flutter speeds, dynamic responses in atmospheric disturbances, automatic devices to decrease induced structural loads, and the effect of operating conditions on structure weight and on the equipment necessary to make the aircraft suitable for passengers are some of the main topics to be treated. Also to be examined are the questions of performance of a propeller turbine operating away from optimum altitudes and temperatures, provision for engine failure, and engine anti-icing as a consideration in allocating fuel reserves. The concluding portion of Mr. Russell's lecture will be devoted to a study of the potential scope of long-range civil transport aircraft.

▸ **18th Annual Meeting.**—The I.A.S. Eighteenth Annual Meeting will be held in the Hotel Astor in New York City from January 23 to 26, 1950. Four days of Technical Sessions are being scheduled on the subjects of Aerodynamics, Aircraft Design, Flight Propulsion, Structures, Instruments, Rotating Wing Aircraft, Air Transport, and Meteorology. This year's plans call for approximately 50 papers to be presented by leading scientists and engineers. Joint sessions will be held with the American Helicopter Society and American Meteorological Society.

The Honors Night Dinner will be held in the Grand Ballroom of the Hotel Astor on Monday evening, January 23. The John Jeffries, Robert M. Losey, Sylvanus Albert Reed, and Lawrence Sperry awards will be presented, and Fellows for 1950 will be named.

The names of speakers at the Honors Night Dinner and at the luncheons to be held during the Technical Sessions will be announced later.

The I.A.S. Annual Business Meeting will be held at 5:00 p.m. on Wednesday, January 25. All members of the Institute are urged to attend.

▸ **Flight Propulsion Meeting.**—In the middle of March, 1950, the Institute will hold its Fifth Annual Flight Propulsion Meeting in Cleveland. The I.A.S. Cleveland-Akron Section, under the able Chairmanship of Arch T. Colwell, Vice-President, Thompson Products, Inc., will be host to members attending the Meeting.

Arch T. Colwell, Cleveland-Akron Chairman, who will be host at the Flight Propulsion Meeting next March.

▸ **Section Activities.**—Nineteen I.A.S. Sections, located at focal points of aeronautical activity in the U.S. and Canada, will sponsor during the coming season activities designed to make I.A.S. members more directly acquainted with current progress. An event of this nature was held by the New York Section on October 8—a tour of the Navy Special Devices Center at Sands Point, L.I., N.Y. Members visiting the Center saw methods and devices used in developing or evaluating training aids for all branches of the U.S. Navy and witnessed demonstrations of navigational and meteorological equipment, ordnance, radar, and television. Such inspection trips to industrial and Governmental facilities—together with monthly meetings, discussion periods, and motion-picture showings—also serve to bring I.A.S. members closer together in their professional relationships.

1949 Guggenheim Medalist

Dr. Edward P. Warner
. . . "pioneering in research and a continuous record of contributions to the art and science of aeronautics."

Edward Pearson Warner, President of the Council of the International Civil Aviation Organization, has been chosen as the recipient of the Daniel Guggenheim Medal and certificate for 1949. The award, announced by Glenn L. Martin, Chairman of the Medal Board, was made for "pioneering in research and a continuous record of contributions to the art and science of aeronautics."

▶ **Engineer and Government Expert**—Dr. Warner's record in the cause of aviation progress is a long and outstanding one. A graduate of Harvard University and the Massachusetts Institute of Technology, he has been, at various times during his career, physicist, professor of aeronautical engineering, consultant, author, editor, and Government expert on aviation problems, both technical and regulatory. He taught aeronautical engineering at M.I.T. from 1920 to 1926 and held the post of Assistant Secretary of the Navy for Aeronautics from 1926 to 1929.

From 1929 to 1945, Dr. Warner served as a Member of the National Advisory Committee for Aeronautics. Successively during this period, he was also Editor of *Aviation* magazine, Consulting Engineer, Vice-Chairman of the Federal Aviation Commission, and Vice Chairman of the Civil Aeronautics Board. In addition, from March to June, 1941, he was a member of the U.S. Lend-Lease Staff in London. In 1945, PICAO elected him President of the Interim Council, and he remained as Council President when PICAO became a permanent organization (ICAO).

E. P. Warner is also widely known for his articles in aeronautical and national periodicals, for his engineering textbooks, and for his *Aviation Handbook* (1931), which is still an oft-used reference volume.

▶ **I.A.S. Founder**—The name of E. P. Warner is also familiar to all I.A.S. Members for his active and constant participation in Institute affairs. He was one of the small group whose efforts made possible the establishment of the I.A.S. in 1932, and it was he who suggested the name of "Institute of the Aeronautical Sciences" for the new organization. Dr. Warner is an Honorary Fellow and Benefactor of the Institute and an Honorary Fellow of the Royal Aeronautical Society. His other awards include the Wright Medal of the S.A.E. (1932) and the Medal of the Aéro Club de France (1927).

F.A.I. Re-Elects Enyart

The Federation Aeronautique Internationale at its 42nd Annual Conference, held in the U.S., re-elected Willam R. Enyart, A.F.I.A.S., as President of the world aviation association governing air records and other civil air events.

Mr. Enyart, who is President of Simmonds Aerocessories, Inc., Tarrytown, N.Y., is the first American to head the body, which held its final sessions for the year in New York. Earlier meetings took place in Cleveland and Washington.

▶ **Others Elected**—Among the several Vice-Presidents elected for the coming years was Capt. John Jay Ide, U.S.N.R., A.F.I.A.S., Park Avenue, New York City. In addition, Roger Wolfe Kahn, M.I.A.S., Grumman test pilot and chief timer at many National Air Races in this country, was named to the Federation's court of appeals on record events.

Advanced Design Characterizes Martin XB-51 Support Bomber

The first experimental model of the U.S.A.F.'s first three-jet airplane, the Martin XB-51 ground-support bomber (see cover), is now undergoing final check-out of its auxiliary systems and equipment preliminary to ground and taxi tests that will precede its first flight. It is the first postwar airplane designed expressly for attack on surface targets in cooperation with Army Ground Forces.

▶ **Design Details**—The specifications and photographs thus far released disclose thin high-speed wings swept back at a 35° angle, horizontal tail surfaces swept back 35° and mounted on top of the vertical tail surface, and "spoiler-type" ailerons on the upper surfaces of the wings to afford lateral control. Wing span is about 55 ft., and fuselage length is approximately 80 ft.

Three turbojet engines power the XB-51. Two of these are mounted on pylons along the lower sides of the fuselage near the cockpit, and the third is built into the rear of the fuselage.

A two-man crew—pilot and radio operator-navigator—are required to fly the XB-51. Landing gear is of the tandem or bicycle type, which was developed by the Martin company and installed in an earlier aircraft, the Martin XB-48.

Curtiss-Wright Appointee: *Leslie E. Neville who has joined the Curtiss-Wright Corporation, Wood-Ridge, N.J., as Assistant to Robert L. Earle, Senior Vice-President.*

Neville Appointed Curtiss-Wright Aide

Leslie E. Neville, former Director of the Standard Aeronautical Indexing System, research project recently completed under contract by the I.A.S., has been appointed as assistant to Robert L. Earle, Senior Vice-President of the Curtiss-Wright Corporation.

▸ **Half-Ton Report**—The final report of the S.A.I.S. staff as submitted by Les Neville to the Central Air Documents Office, Wright-Patterson Air Force Base, Dayton, embodied approximately 1,000 lbs. of material, including the division, section, and subject heading breakdown evolved through coordination with more than 2,000 of the leading authorities in aeronautics and related fields.

In addition, a list of the authorities contacted and recommendations for continuation of the coordination activity by CADO was submitted.

Completion of the S.A.I.S. marks a new milestone in the history of documentation for which a large share of credit goes to Les for his participation as Director. For the first time, a field of knowledge has been broken down on a truly functional basis by the process of interview and discussion with hundreds of specialists in the various segments of the field. The breakdown therefore represents a faithful replica of the entire field of aeronautics.

▸ **With Aviation 20 Years**—Mr. Neville, who has been closely associated with aviation for twenty years, joins Curtiss-Wright in a public relations capacity.

He is the author or coauthor of several books, including *Jet Propulsion Progress* and the forthcoming *Aviation Handbook for Aircraft Designers*, published by McGraw-Hill Book Company, Inc.

Caldwell Wins Scott Award for Prop Development

Frank W. Caldwell, H.F.I.A.S., Director of Research at United Aircraft Corporation, received the John Scott Award on September 19 for the development of the controllable-pitch propeller. The medal of the 133-year-old John Scott Medal Fund was presented before the boys of Girard College in the school chapel at Philadelphia.

Importance of the propeller to aviation progress was recognized in 1933 by the award of the Collier Trophy for the year's most valuable contribution to aviation to Hamilton Standard "with particular credit to Frank Walker Caldwell." In 1935 he was given The Sylvanus Albert Reed Award by the I.A.S. for his work on the controllable-pitch and constant-speed propellers.

▸ **In Charge of Research**—As Director of Research at United Aircraft, a post he had held since 1940, Mr. Caldwell is in charge of research projects in the corporation's extensive laboratories for all four of the operating divisions.

He was President of the Institute of the Aeronautical Sciences in 1941 and was made an Honorary Fellow in 1934.

Two Aero Specialist Firms Join Institute

Two firms specializing in aeronautical design and products have joined the I.A.S. as Corporate Members: Aerolab Development Company, Inc., and Brooks & Perkins, Inc.

▸ **Special Equipment Source**—organized in February, 1945, for the express purpose of providing a source of design and manufacture of various items of specialized equipment incident to research and development in aeronautics laboratories, Aerolab Development is located at 1992 Lincoln Ave., Pasadena 3, Calif.

Products range from high-speed gear boxes for wind-tunnel models, the models and tunnels themselves, balances and instruments for models and tunnels, supersonic models, supersonic tunnels, parts and equipment for experimental aircraft, rocket valves, regulators, etc., to development of special machinery for model construction, propeller blades, tapered wing skins, development work on titanium metal parts, precision axial compressor blading, missiles and missile components, etc.

In addition, the company has an interesting line of standard products. Largest among these is a complete vertical closed return wind tunnel for industrial and educational use. Because of multiple production from one design, colleges and industry may have a superior tunnel (through improvement of successive models) at a cost far lower than the design and building of one tunnel would be to any single group.

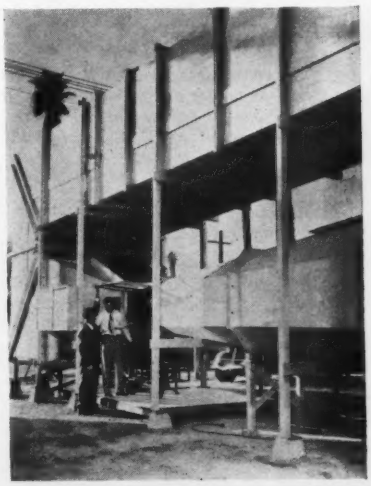
The tunnel can be supplied either vertical, horizontal, or vertical inverted between floors of a tall building with the working section on the floor of the upper story and the return section suspended from the ceiling of the lower story. All styles sell for the same price of $13,450.

▸ **Demonstration Tunnels**—Other products are the "Smokestream, Sr." and "Smokestream, Jr.," large and small two-dimensional, visual-flow wind tunnels for demonstration purposes.

A continuous supply of dense white smoke is supplied by a special generator and the airstream carries filaments of this smoke in nonturbulent flow past a model. The larger model is 5 ft. long, while the smaller is less than 2 ft. and can be carried in one hand and stored on a bookshelf.

▸ **Magnesium Products**—Brooks & Perkins, Inc., with offices at 2457

Wind Tunnel Available: *Aerolab Development Company, Pasadena, Calif., counts among its standard products available to colleges and industry this complete closed return wind tunnel. Tunnel can be supplied either vertical, horizontal, or vertical inverted between floors of a tall building. Overall dimensions are 55 ft. long, 18 ft. high, and 10 ft. wide. Working section is 32 by 45 in., large enough to accommodate a 3-ft. model, and airstream velocity is 175 m.p.h. All styles sell for the same price of $13,450, far lower cost than cost of designing and building one tunnel only.*



Woodward Ave., Detroit, have complete facilities at 1957 W. Lafayette Blvd., Detroit, for the building of prototype models and specialized equipment for production manufacturing of magnesium assemblies.

Their large engineering staff is equipped for product and tool design, as well as complete lofting service.

Current programs include such items as the magnesium gun enclosure and dome assemblies for large Air Force bombers, as well as radar reflectors and associated equipment, radar plotting units, instrument housings, aircraft seats, air-frame subassemblies, and many deep-drawn and miscellaneous stampings.

▶ **Publishes Magazine**—With the increasing emphasis on weight reduction in both military and commercial planes, magnesium has become one of the most important of aircraft materials. *The Magazine of Magnesium* is published quarterly by the company and contains valuable information on all phases of magnesium design and fabrication. This service is available on request without charge to designers, engineers, and interested manufacturers.

Brooks & Perkins work on a contract basis for the Air Force, Navy BuAer, air-frame manufacturers, electronic and armament manufacturers, and others.

U. S. Jet Transport Awaits Funds and Planning, Wellwood Beall Says

Boeing Airplane Company has on its drawing boards advanced-type jet transports that are the next logical step ahead of anything now flying abroad. Boeing studies show them to be not only economically feasible but absolutely essential to a well-rounded defense department, it was declared by Wellwood E. Beall, F.I.A.S., Vice-President of Engineering and Sales.

National Meetings Calendar

Dec. 17	Wright Brothers Lecture, Washington, D.C.
Jan. 23–26, 1950	Eighteenth Annual Meeting, New York.

For details see page 71

▶ **Stopped in Tracks**—But, he said, "manufacturers in this country are for the moment stopped dead in their tracks."

While Britain's subsidized aircraft industry has built and flown no less than six different jet-powered air liners and is in production on some of these, Beall said, we not only do not have a commercial prototype flying in this country but have not begun construction of an experimental model.

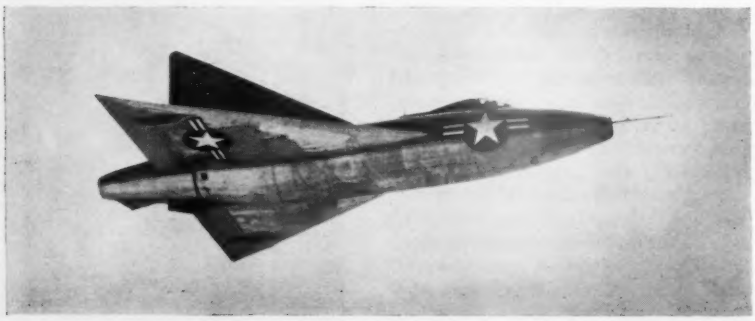
Because of the very nature of aircraft design and development work, he went on, no company can risk its capital in the building of a wholly new type of airplane such as the jet transport. Further, no manufacturers in this country can complete engineering work on such a new type without having even an inkling of Government certification standards and operating criteria, he said.

▶ **What Is Needed**—Claiming that Boeing could build and fly a prototype 500-m.p.h. jet transport in 18 months, Beall said the following steps are a prerequisite:

- **Changes in C.A.A. regulations,** setting up performance and operating standards for jets, will be required to certificate this new type of equipment.
- **Revision of airways** procedures and airport landing facilities.
- **Government financial aid,** if we are to overtake and pass the subsidized British aircraft industry in its bid for domination of the future jet transport field.

60-DEGREE SWEEPBACK

Wings of the Convair XF-92A delta-wing research interceptor are swept back at an angle of 60°. Sweepback does not exceed 35° in other current interceptor types. The jet-powered XF-92A has elevons for aileron and elevator action. The vertical stabilizer and rudder provide directional control and stability. Photograph was taken as experimental U.S.A.F. aircraft flew over Muroc Air Force Base, Calif.



I.A.S. Members Honored by Aero Medical Association

The Aero Medical Association, at its twentieth annual meeting held in New York City, honored four Institute members by awards and election to office.

Colonel Arnold D. Tuttle, U.S.A.F. (ret.), M.I.A.S., Medical Director of United Air Lines, was elected President. He will take office at the close of the next annual meeting to be held in Chicago in the latter part of May, 1950.

Dr. Paul A. Campbell, A.F.I.A.S., Consultant in Aviation Medicine, Chicago, Ill., was named Chairman of the Scientific Program Committee for the 1950 meeting.

The 1949 Theodore C. Lyster Award for achievement in the general field of aviation medicine went to Major Gen. Harry G. Armstrong, F.I.A.S., Deputy Surgeon General, U.S.A.F. The presentation was made by Dr. Louis H. Bauer, M.I.A.S., Editor of the *Journal of Aviation Medicine*. General Armstrong also was elected a Vice-President of the Association.

In addition, Col. Robert J. Benford, U.S.A.F., M.I.A.S., was elected a Fellow in Aviation Medicine.

I.A.S. Members Receive New 1949–1950 Roster

Copies of the new I.A.S. 1949–1950 ROSTER OF MEMBERS were mailed to all I.A.S. Members during the latter part of September. The new ROSTER, which contains over 7,000 listings, is the latest complete reference to I.A.S. Members, Corporate Members, Sections, Student Branches, Committees, and Officers. It is also a useful guide to I.A.S. Honors and Awards, Services, Publications, and Membership Requirements.

Members are urged to notify the Institute immediately of any changes in employment or address, so that our records will be accurate and up to date. In this way Members will receive publications and correspondence without unnecessary delay.

S.E.S.A. Meeting Announced

The Society of Experimental Stress Analysis, P.O. Box 168, Cambridge 39, Mass., announces that its Annual Meeting will be held at the Hotel New Yorker, New York, N.Y., on November 30 and December 1 and 2, 1949.

Corporate Member News

• Oscillator for 300–2,500 Megacycles. . . **Airborne Instruments Laboratory's** new Type 124A Power Oscillator, designed for measurement and testing in the 300- to 2,500-megacycle range, consists of a grid co-axial oscillator employing a 2C38 disc-seal triode. It contains an integral 115-volt 50–60 cycle per sec. power supply, an audio oscillator and modulator section, and provision for external modulation. Delivery on single orders will be made within 6 months, with frequent production runs expected to expedite deliveries.

• **Aircraft Radio Corporation** has announced an isolation amplifier to enable pilot or copilot to select independently and without cross-talk any combination of ten receivers, interphones, or similar equipment and to provide loudspeaker operation to both pilot and copilot. The amplifier, Type F-11, carries C.A.A. Type Certificate No. 1R4-1. . . Another new product is Type A-13 V.H.F. navigational aircraft antenna, with C.A.A. Type Certificate No. 1R4-4. It covers the 105–122-megacycle band and is designed for reception of omnirange and runway-localizer signals.

• Supersonic Compressor . . . N.A.C.A. and **Allis-Chalmers Manufacturing Company** have released design details of a 4- by 4-ft. wind tunnel at the Langley Aeronautical Laboratory, which has been in preliminary operation for the past year. Air velocities from 1.2 to 2.2 times sonic velocity are obtained with a seven-stage axial compressor built by Allis-Chalmers. The 11-ft. diameter, 1,137-blade compressor rotor is constructed of seven forged steel discs and two forged steel shaft ends welded together. Total weight of the rotor is about 65 tons. The entire compressor produces a flow of as much as 870,000 cu.ft. of air per min. Up to 60,000 hp. are required to drive the unit.

• Overseas Teletype . . . Messages pertaining to return-trip bookings, hotel reservations, and other passenger services are being handled by **American Airlines System** over a private teletype channel linking U.S. offices with American Overseas Airline stations in Europe.

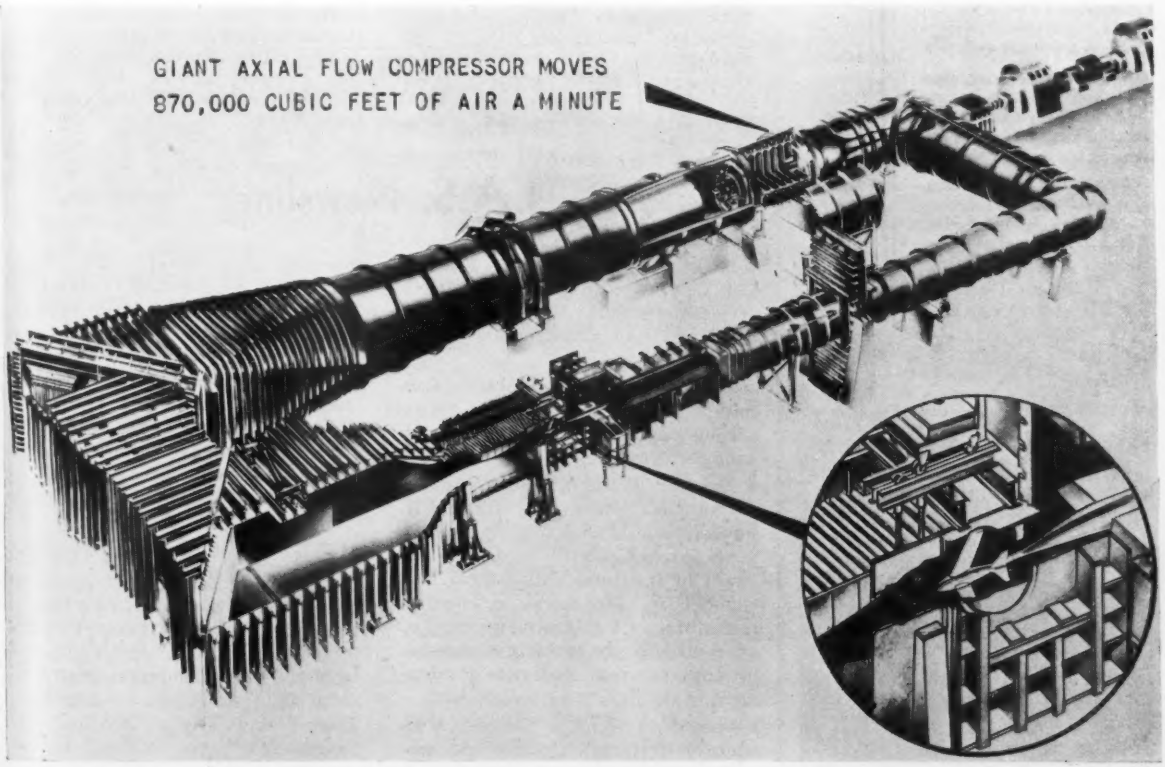
• A.O.A. Sale Agreement Extended . . . The contract between **American Overseas Airlines, Inc.,** and Pan American Airways, Inc., relating to the sale of the assets of A.O.A. to P.A.A. has been extended to March 13, 1950, by mutual consent. The present agreement provides that Pan American shall pay $17,450,000 in cash for Overseas' assets and shall assume the latter company's liabilities at the date of closing. On March 13, either party will have the right to extend the agreement to June 13.

• $2,000,000 Plant Expansion . . . **Canadair, Ltd.,** will construct an extension to its present Plant No. 1, near Montreal, which will provide over 200,000 sq.ft. of additional floor space. This expansion is a result of an order received from the Canadian government for 100 F-86A "Sabre" jet fighters to be delivered to the R.C.A.F. The new facilities will be used for manufacture of aircraft parts and the fabrication and assembly of tools, dies, jigs, and fixtures.

• Convair Reports Net Profit . . . A net profit of $1,585,327 is reported by **Consolidated Vultee Aircraft Corporation** for the 6 months ended May 31, 1949. For the same period of 1948, the company suffered a net loss of $7,534,419. An increase in working capital of $1,324,000 was noted for the first half of the current fiscal year. The month of June, 1949, saw a further increase of working capital to the amount of $431,000.

• Quieting Aircraft Radio . . . The U.S.A.F. has awarded a contract to the **Airplane Division of Curtiss-Wright Corporation** to look into the causes and possible elimination of noise and interference in aircraft radio and electronic equipment. The studies, which are to extend for more than a year, will be conducted in a copper-shielded laboratory and in a B-17 bomber furnished by the U.S.A.F. Noise elimination will be sought in methods other than the conventional use of filters. The noise

Four by Four-Ft. Supersonic Pressure Tunnel at the N.A.C.A. Langley Aeronautical Laboratory: *The size of the test section of this wind tunnel, which has been in preliminary operation for more than a year, allows the use of models large enough for installation of extensive instrumentation. For example, a 32-in. span model of a complete supersonic airplane is now being investigated which is fitted with movable controls and more than 300 pressure orifices. The 140-ton compressor unit was built by the Allis-Chalmers Manufacturing Company. Inset shows complete model airplane installed in the test section.*



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problem has been emphasized by the current practice of employing unshielded wiring not in conduit.

• Super DC-3 . . . **Douglas Aircraft Company, Inc.** has received an order for three new Super DC-3 airplanes from Capital Airlines, Inc. Delivery is expected in the early spring of 1950.

• Human Centrifuge . . . The **General Electric Company** is building special power and control equipment for a human centrifuge to be installed next year at the Naval Aviation Medical Acceleration Laboratory, Johnsville, Pa. The gondola, in which the subject will be seated, will be attached to a 50-ft. arm driven by a 4,000-hp. motor. Tipping and turning of the gimbal-mounted gondola is to be directed by an electronic control system. Pilots undergoing tests will be subjected to accelerations as high as 40 *g*. The centrifuge is being constructed by McKiernan and Terry Corporation under the direction of the U.S. Navy Special Devices Center at Sands Point, Long Island, N.Y.

• Forming by Marform . . . Savings as high as 50 per cent in forming of sheet-metal parts are reported for a process developed by **The Glenn L. Martin Company.** Production rate of detailed parts is increased, and close dimensional tolerances can be observed with less expensive tooling and labor. Basis for the success of the process, called "Marform," is the precision control of the pressure curve for the forming cycle of the part. Parts formed with this control are free of wrinkles, and springback is at a minimum. Stainless-steel exhaust stacks, for example, can be formed at the rate of 50 per hour as compared with the rate of 3 or 4 per hour with a drop-hammer process. . . The Martin company has received an order from the National Military Establishment for a production quantity of KDM-1 high-speed sweptback wing targets, improved versions of the Martin Gorgon IV. Pilotless and radio-controlled, the KDM-1 target drone is powdered with a 20-in. Marquardt ram-jet engine. Delivery will be made to the U.S. Navy in the near future.

• Ryan Robots Reordered . . . **Ryan Aeronautical Company** has received a million-dollar contract from the U.S.A.F. to produce additional XQ-2 remote-controlled jet target planes. The original contract, signed over a year ago, was for approximately $2,000,000.

• Declares Dividend . . . A 25-cent dividend was paid October 8 to stockholders of record September 16 by **Stewart-Warner Corporation.** It was the fourth dividend paid this year.

• A magnetic tape recorder for guided-missile research has been developed at **United Aircraft Corporation** for the U.S. Navy Bureau of Ordnance. In this recorder, a magnetic steel tape, which is 6 in. in width and 150 ft. in length, is led into an armored container housed in the nose of the missile. The steel tape lacks the disadvantages of fragile, combustible paper tape and light-sensitive photographic film, and it can withstand without injury the impact of the spent missile into the ground. Atmospheric and missile performance data can be recorded for as many as 110 sec. of flight. The recorder was developed by Armour Research Foundation under subcontract to United Aircraft Corporation in association with M.I.T., Bell Aircraft Corporation, and Bendix Aviation Corporation. A still smaller version of the device is also being developed.

• J-34 Passes 150-Hour Test . . . A production **Westinghouse Electric Corporation** Jet engine, Type J-34, has successfully passed the 150-hour Air Force-Navy qualification test. It is the first engine of any make or rating to attempt and complete the test, which subjects engines to severe simulated service conditions. During the operation of the engines through a regular pattern of cycles from idling to full military output, virtually no parts may be replaced, and routine inspections are rigidly limited.

I.A.S. Newslines

▸ **Major G. P. Bulman,** F.I.A.S., C.B.E., previously with the Air Ministry, is now with the Ministry of Supply as Director of Construction of Research Facilities.

▸ Italian Consultant . . . **Mario Castoldi,** F.I.A.S., is an Aeronautical Consulting Engineer with offices on Trezzano Sul Naviglio, Milano, Italy.

▸ Awarded Wetherill Medal . . . Inventor of the Fowler flap, **Harlan D. Fowler,** A.F.I.A.S., was awarded a John Price Wetherill Medal by the Franklin Institute, Philadelphia, last October 19. Medal was presented in recognition of Fowler's many years of effort to solve the problem of variable lift airplane wings, leading to development of the flap.

▸ Named to Defence Board . . . Minister of National Defence has announced appointment of **Dr. John J. Green,** A.F.I.A.S., of Ottawa, as Deputy Director General of the Defence Research Board and Scientific Adviser to the Chief of Air Staff, Canada. Dr. Green left the Canadian Air Transport Board to accept the appointment. His professional career has been almost wholly devoted to research, development, and testing (both laboratory and flight) in aviation.

▸ New Chief of Research . . . **Abe Silverstein,** F.I.A.S., has been named Chief of Research at the Lewis Laboratory, filling a vacancy created by transfer of Addison M. Rothrock, F.I.A.S., to N.A.C.A.'s Washington Staff some time ago. As Chief of the Wind Tunnel and Flight Division, Mr. Silverstein's previous post, he had

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responsibility for directing research in the Altitude Wind Tunnel, Icing Research Tunnel, supersonic wind tunnels, and flight research activities.

▶ Moves West...**Paul Torda,** A.F.I.A.S., has joined the faculty of the University of Illinois, College of Engineering, as Associate Professor of Aeronautical Engineering. He formerly was Research Associate, Senior Grade, at Brooklyn Polytech. New address is Department of Aeronautical Engineering, College of Engineering, University of Illinois, Urbana, Ill

News of Members

Lieutenant O. K. Bell, M.I.A.S., formerly Television and Telemetering Officer at the Naval Air Missile Test Center, Pt. Mugu, Calif., has been transferred to a similar post at the Joint Long Range Proving Ground, Cocoa, Fla.

Victor E. Bertrandias, A.M.I.A.S., resigned as Vice-President and Director of Foreign Sales, Douglas Aircraft. He has not announced his future plans.

Lloyd B. Bertholf, M.I.A.S., Airline Meteorologist for Pan American, has transferred from Brownsville, Tex., to New Orleans. New address: Meteorology Department, Pan American Airways, Box 241, New Orleans 3, La.

Kenneth P. Bowen, M.I.A.S., became Assistant Vice-President of Northrop Aircraft last September 5, assigned to the office of B. G. Reed, Northrop Vice-President in Charge of Production. Mr. Bowen formerly was Assistant General Manager of Fairchild Aircraft Division, Hagerstown, Md.

Samuel Leo Burgess, Jr., A.M.I.A.S., is Operations Engineer Agent for All-American Airways at Washington, D. C.

Douglas Campbell, A.M.I.A.S., was decorated with the "Order of the Sun" by the Peruvian Government last September for his part in pioneering and developing transportation between Peru and the U.S. Mr. Campbell, Vice-President and General Manager of Panagra, received the award in a ceremony at the Peruvian Embassy in Washington, D. C.

Lewis H. Chow, M.I.A.S., is Group Leader (Experimental Group) for Canadair, Ltd. He lives at 3170 Van Horne Ave., Apt. 8, Montreal, P.2, Canada.

Carmine John Colaluca, Jr., T.M.I.A.S., is Experimental Test Engineer for Ranger Aircraft Engine Division of Fairchild, Farmingdale, N.Y.

Douglas E. Eastman, Jr., T.M.I.A.S., is now employed by Boeing Airplane Company, Seattle. New address is 3013 11th N., Renton, Wash.

Tom U. Engelman, M.I.A.S., has resigned as Director of Public Relations for Grand Central Airport Company and is in business for himself in the publicity and promotion field. He had been with the company since 1946.

Leland Ray Fine, T.M.I.A.S., is Structural Draftsman for the Indiana State Highway Commission, Indianapolis.

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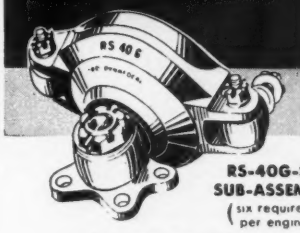

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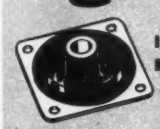

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CONVAIR 15-YEAR MAN

J. W. Larson, M.I.A.S., (left), Chief Engineer at Convair's Fort Worth division, receiving a 15-year service pin from R. C. Sebold, Director of Engineering. Larson joined the firm (then Consolidated Aircraft Corporation) in Buffalo in August, 1934. Prior to that he worked for Curtiss Aeroplane and Motor Corporation following his graduation from the University of Utah in 1928. In 1942 he transferred from Convair's San Diego division to Fort Worth as Chief Design Engineer and was elevated to Assistant Chief Engineer in 1945 and to Chief Engineer last March. Sebold has been with company 19 years.

Hubert I. Flomenhoft, T.M.I.A.S., is with the Bureau of Aeronautics, Navy Department, as Structural Load Engineer, Design Elements Division. New address: 1112 N. Kenebec St., Arlington, Va. He previously had been Research Engineer at M.I.T.

Frank W. Godsey, Jr., M.I.A.S., is Manager of new Special Products Development Division formed recently by Westinghouse Electric. He previously directed the New Products Department, now absorbed by the new division.

Robert A. Goodpasture, M.I.A.S., formerly Research Engineer with Douglas Aircraft, Santa Monica, is now with The RAND Corporation in the same capacity.

Dr. Clinton R. Hanna, M.I.A.S., Associate Director of the Research Laboratories, Westinghouse Electric Corporation, Pittsburgh, has been awarded the Howard N. Potts Medal in recognition of his initiative in the conception and development of the Tank Gun Stabilizer. The invention won for him the Presidential Citation in 1942.

John S. Karwoski, T.M.I.A.S., is Aeronautical Engineer at The Kellex Corporation, 936 Wayne Ave., Silver Spring, Md., in the Silver Spring Laboratory.

Hans P. Liepman, M.I.A.S., resigned as Chief Aerodynamicist of Goodyear Aircraft Corporation to become Director of the Supersonic Wind Tunnel in the Engineering Research Institute and Lecturer in Aeronautical Engineering in the College of Engineering, University of Michigan, Ann Arbor, Mich. New address is 1418 Henry St., Ann Arbor.

Kenneth R. MacDonald, A.M.I.A.S., has left the San Francisco Chamber of Commerce where he has been Manager of the Aviation Department for the past 5 years. Because of a restricted budget, Chamber has closed the Aviation Department and has absorbed some of the activities in other units.

W. E. Rohman, M.I.A.S., resigned as Aeronautical Sales & Service Manager of Thomas A. Edison, Inc., Instrument Division.

Lawrence A. Smith, T.M.I.A.S., has been appointed to the N.A.C.A. staff at the High Speed Flight Research Station, Muroc, Calif.

Professor M. H. Vavra, M.I.A.S., has been promoted from Associate Professor to Professor of Aeronautics at the U.S. Naval Postgraduate School, Annapolis, Md.

I.A.S. Sections and Student Branches

Cleveland-Akron Section

W. A. Fleming, *Secretary-Treasurer*

At a meeting September 8 of the officers and advisory board to discuss the program for the coming year, Dr. Robert S. Ross was appointed Acting Vice-Chairman from Akron to fill the vacancy left by resignation of H. P. Liepman.

A Publicity Committee and a Membership Committee were established. Appointed as Chairman of the Publicity Committee was H. C. Chandler of Cleveland with Fred J. Stimler acting as his Assistant.

ON WEST VIRGINIA FACULTY

Leon Z. Seltzer, former Production Engineer for Fred Seltzer Company, Chicago, has joined the faculty of West Virginia University, where he is now Professor of Aeronautical Engineering and Head of the Department of Aeronautical Engineering.

Howard F. Powders was requested to act as Chairman of the Membership Committee.

Dayton Section

W. A. Barden, *Secretary*

A meeting was held August 24 at the Miami Valley Golf Club at which films were shown, including a Spike Jones musical, *Battle of Midway*, and *Report from the Aleutians.*

Cal-Aero Technical Institute

"Recent Events in Soaring Flight" was the subject presented at the August 2 meeting by Dr. Wolfgang B. Klemperer, Douglas Aircraft Research Engineer. Nick Reid, Chairman, presided at the meeting attended by 130 members and guests.

Formerly of Dresden, Germany, Dr. Klemperer is noted as one of the first engineering physicists to work on rocks before they were considered practical. He is currently working on guided missiles.

Air Cargo Day

Hotel Statler, New York City, Tuesday, November 29

All-day cooperative meeting of the I.A.S., A.S.M.E., and S.A.E. will feature technical papers on air-cargo problems, inspection trip to Newark Airport, and display of an activated model of the air cargo terminal of the future. Dr. Hugh L. Dryden, Director, N.A.C.A., will be guest luncheon speaker.

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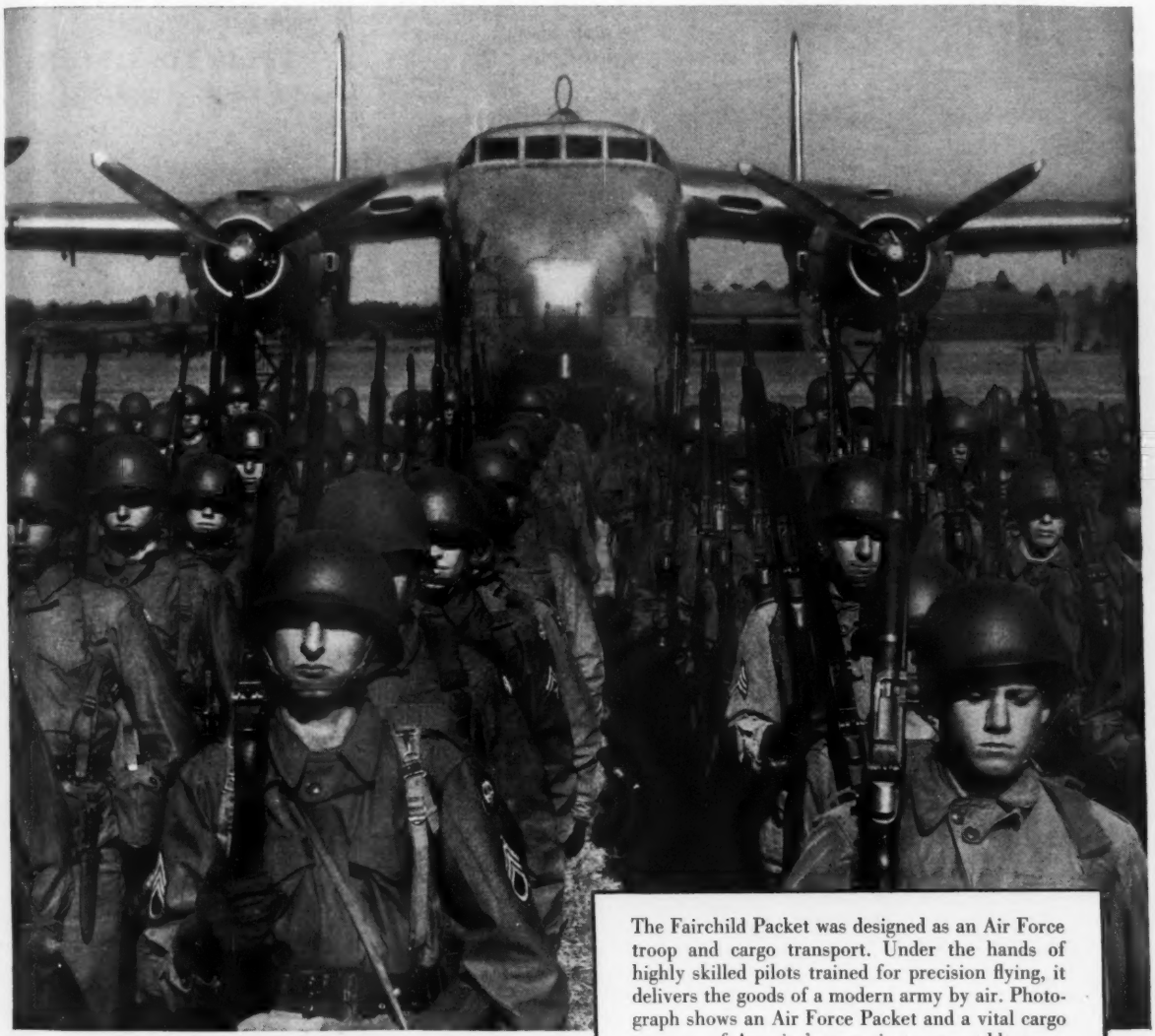

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Most recent purchaser of Constellations is the Chicago & Southern Air Lines, which recently bought five Constellations. In 1949 alone, five major world airlines ordered a total of 41 new Constellations.

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Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Transferred to Associate Fellow Grade

Dykes, John Christopher, M.A., M.S. in Ae.E., A.F.R.Ae.S., M.S.A.E., Asst. Technical Development Dir. (Engineering), British Overseas Airways Corp. (London).

Greene, Leonard Michael, Ph.D., President and Treasurer, Safe Flight Instrument Corp.

Hamlin, Benson, B.Ae.E., Project Engineer, Air Forces Guided Missile Project, Bell Aircraft Corp.

Nilakantan, Parameswar, Dr.Sc., Deputy Dir., Research and Development, Civil Aviation Dept., Govt. of India.

Roberts, Howard Emery, A.E., Group Leader, Aero-Thermodynamics Group, Douglas Aircraft Co., Inc.; Consulting Aerodynamicist, AeroLab Development Co.

Woodham, Ruland M., M.E., Administrator, Standard Aero. Indexing System, Institute of the Aeronautical Sciences, Inc.

Elected to MEMBER Grade

Alexander, E. J., A.A., Design Engineer, Hughes Aircraft Co.

Canaday, Robert F., Asst. Washington Representative, Douglas Aircraft Co., Inc.

Davis, Edgar S., Vice-President, Wings, Inc.

Hartley, Croydon H. A., Asst. Project Engineer, The Glenn L. Martin Co.

King, Leighton S., M.S., Chief Preliminary Design Engineer, AiResearch Mfg. Co.

Klopp, James W., B.S. in M.E., Comdr., U.S. Navy; Bureau of Aeronautics Resident Representative, Piasecki Helicopter Corp.

Lambert, Arthur A., Jr., B.S.Ae.E., Project Aerodynamicist, McDonnell Aircraft Corp.

Lippisch, Alexander M., Dr. (Physical Sciences.)

Manildi, Joseph F., Ph.D., Asst. Professor, College of Engineering, University of California at Los Angeles; Dir. of Research, G. M. Giannini & Co., Inc.

Murphy, Frank W., B. of Ae.E., Asst. Landing Gear and Hydraulics Engineer, Douglas Aircraft Co., Inc. (Santa Monica).

Murray, Lester K., Missile Test Group Engineer, Consolidated Vultee Aircraft Corp.

Newton, Johannes S., B.E. in M.E., Research Engineer, North American Aviation, Inc.; Consulting Engineer, The Icelander Airlines.

Paulsen, Orville B., B.S. in M.E., Flight Test Engineer, Douglas Aircraft Co., Inc.

Reynolds, Lawrence B., M.S. in Ae.E., Chief, Flight Loads Group, Structures Branch, Air Materiel Command, Wright-Patterson Air Force Base.

Rothman, Maurice, Ph.D., Lecturer in Mathematics, The Royal Technical College (Glasgow).

Sadler, Carl L., Jr., B.S.M.E., Asst. Chief Engineer, Hydraulic Div., Sundstrand Machine Tool Co.

Scurlock, Arch C., Sc.D., Vice-President, Atlantic Research Corp.

Smith, John G., Technical Asst., Pan American World Airways System.

Steel, Donald William, M.S. in M.E., Project Engineer, Thrust Producing Mechanisms Section, Propulsion Div., U.S. Naval Ordnance Test Station (Pasadena).

Sutton, George P., M.S., Supervisor, Propulsion Development, North American Aviation, Inc.

Webster, Howard E., M.S. in C.E., Lt. Col., U.S.A.F.; Student, Air War College, Maxwell Air Force Base.

Whalen, John A., Liaison Engineer, Rohr Aircraft Corp.

Winter, Norman L., B.S.E.E., Asst. to Vice-President and General Sales Mgr., Sperry Gyroscope Co. Div., The Sperry Corp.

Withee, Wallace W., B. of Ae.E., Design Specialist, Consolidated Vultee Aircraft Corp.

Yeager, Donald L., B.S.M.E. (Aero.), Field Engineer P-4, Los Angeles Air Materiel Command Engineering Field Office.

Transferred to MEMBER Grade

Barkley, William B., B.S.M.E. (Aero.), Hydrodynamic Research Engineer, Consolidated Vultee Aircraft Corp.

Cleveland, Frank Allen, II, M.A., Aerodynamics Engineer, Lockheed Aircraft Corp.

Dickson; John A., M.S., Development Engineer, Molded Latex Products, Inc.

Eck, Carl F., B.S. in A.E., Engineering and Air Safety Representative, Air Line Pilots Association.

Martin, Thomas J., M.S. in E.E., Development Engineer, Aircraft Electrical Systems, Boeing Airplane Co. (Seattle).

Steele, Theodore Karl, M. of M.E., Instructor, New York University.

Elected to Technical Member Grade

Goel, Radhey Shyam, Radio Technician, Civil Aviation, Ministry of Communications, Govt. of India.

Jenno, Charles Henry, Asst. Chief Technician, Aero Controls, Ltd. (England).

Paiss, Harold, B.S. in M.E., Administrative Maintenance Engineering, Self-employed.

Sanders, William C., B.S.M.E. (Aero.), Stress Analyst, Vibration and Flutter Dept., Boeing Airplane Co. (Seattle).

Smith, Richard C., Designer, Aircraft Interiors, Consolidated Vultee Aircraft Corp.

(*Continued on page 79*)

Editorial

S.A.I.S.—Final Report

> "—with reference to the termination of the contract, we have notified the Procurement Division, Headquarters Air Materiel Command, that the IAS has completely fulfilled its obligations under the terms of the contract . . . Again, thank you and your associates for your splendid cooperation and performance in the development of the SAIS."

Thus, in the official language of the U.S.A.F., our 2-year cooperative project with the Air Force and Navy came to an end. It is not, however, the end of the development of the S.A.I.S. The first phase having been successfully completed by the I.A.S., the Central Air Documents Office is taking over for the continuing phases, which, of course, are intimately connected with the work of cataloging and disseminating highly classified material.

We cannot let the occasion pass without extending the sincere thanks of the Officers and members of the Institute to Leslie E. Neville, who directed the project, and to his hardworking staff for the outstanding job that they have accomplished. Their report and its supporting documentation stands as a monument to almost 30 months of unrelenting effort toward the goal that was set and which they reached. Few people realize the vast amount of material that they screened and analyzed. Contact with over 2,000 persons was maintained throughout the project both by correspondence and by staff visitation. To all who contributed (most of whom are members of the I.A.S.) our thanks and appreciation for the time and intelligent thought that was given to our problem. The work of the staff would have been impossible without your cooperation.

Our thanks, too, to the personnel of CADO, and the Air Force. Colonel A. A. Arnhym and his people (to whom we were directly responsible under the contract) were ever helpful with suggestions—were cooperative but never dictatorial. Our relations with the Navy, through Capt. N. A. Draim, U.S.N., have always been of the best, as was the case with all other Government agencies involved. Our several task masters were exacting but always sympathetic and cooperative. It is gratifying to know that our job was completed to their entire satisfaction.

From the I.A.S. point of view, the S.A.I.S. was an experiment. It proved beyond a doubt, however, that there are many ways in which the facilities of the I.A.S. and almost unlimited aggregate of experience in its membership may be utilized in the public interest. There are many other fields in which the facilities that are ours may be used. Several are already being explored. We should be glad to receive, however, any suggestions from the members as to areas in which a contribution of a similar nature might be made by the Institute.

S. P. J.

THE GROUP THAT MADE S.A.I.S. POSSIBLE: A typical conference of S.A.I.S. people and Air Force and Navy personnel. Reading around the table from left to right: Harris F. Reeve, S.A.I.S. staff; Max Sokol, S.A.I.S. staff; Leslie E. Neville, S.A.I.S. Director; Elizabeth Brown, I.A.S. Library staff; Capt. N. A. Draim, U.S.N., Navy Representative; Col. A. A. Arnhym, Director of CADO (our Contracting Officer); Ernest Robischon, then U.S.A.F. Consultant; R. M. Woodham, S.A.I.S. Project Administrator; Keith Brown, S.A.I.S. staff.

I.A.S.-S.S.A. SECOND JOINT

MEETING, ELMIRA, N.Y.

Summary of the Technical Sessions

By
BEN SHUPACK
Aerophysics Institute, Inc.

THE SECOND POSTWAR JOINT MEETING of the Institute of Aeronautical Sciences and the Soaring Society of America was held at Elmira, N.Y. on July 8. The meeting was divided into an afternoon session and an evening session. The morning was available for the inspection of the sailplanes on the ground and their performance in the air. Even the Army contributed to the entertainment just prior to the afternoon session by staging a demonstration of cargo glider towing and a cargo glider pickup, just in front of the meeting room. With the entire audience assembled so conveniently outside the room it was a matter of a few minutes to begin the afternoon session at the end of this thrilling demonstration.

The theme of the afternoon session was "research with and about sailplanes." The elaboration of this theme was presented in a paper, "The Sailplane Project of Mississippi State College," by August Raspet, Engineering and Industrial Research Station of Mississippi State College. Raspet began with his original definition of soaring: "the science of extracting energy from the atmospheric discontinuities with the sailplane." The implementing of this definition required the improvement of the sailplane as an energy extracting device and a microscopic study of the air as the source of the energy.

There is always room for improvement in the use of airfoils and the Sailplane Project is investigating the laminar airfoil not in a wind tunnel but on a full-size flying glider. The lift and moment coefficients will be determined by the pressure distribution as recorded with a commutating pressure recorder. The profile drag will be revealed by an integrating wake rake. A novel investigation will be the effect of noise on the airflow over the wing by the use of generated noise fields of varying frequency and amplitude. In this airfoil research there will be no wind-tunnel correction factors!

Skid control, a topic of great interest in precision and routine flying, is also under investigation. A yawhead is used to detect the skid of the supporting wing, and the rudder responds automatically to the indications of the skid detector by using in the initial experiments a human servo.

A more precise investigation of bird flight is being attempted by formation flying with buzzards (Cathartes and Coragyps) using a calibrated sailplane. Preliminary measurements on turkey buzzards indicate an effective aspect ratio that is 1.25 times the geometric! An examination of the performance curve of the buzzard, Fig. 1, will be interesting if not exciting.

The investigation of the air as a source of energy is being pursued by studying the structure and the physical parameters of convective cells. For this study, three identical sailplanes, performance curves of which have been matched as exactly as possible, are being used as meteorological probes. Raspet concluded by emphasizing the work and flexibility of the glider as a research tool.

The question of the proper configuration of a "Sweptback Wing" was discussed by D. F. Farrar, Jr., of Vanderbilt University. He pointed out that the sweptback wing had become more important with the advent of the tailless and supersonic airplane. The normal sweptback wing is constructed with airfoil profiles designed and tested for straight wings, on the assumption that the flow of air over both types is essentially the same. However, a great deal of published evidence shows the existence of a pronounced cross or spanwise component to the airflow on sweptback and sweptforward wings.

The inherent faults of sweptback wings—such as early tip stalling, reduced maximum C_L, and increased pitching moment, which reduce the efficiency and stability of the wing—may be corrected by designing a wing that will present the desired profile and plan form to the actual airflow. The speaker hoped that the evidence he presented would be sufficient to warrant the necessary tests by a laboratory equipped for such work.

The Report on the D 30 Sailplane by Hans Zacher, Prien Chiemsee, Germany, was given by Harold Flinsch, of Mississippi State College, whose brother was in charge of its building and the initial flights. In fact he established an international goal and return record with the D 30, with its aspect ratio of 33.6:1!

To give all the details of the D 30, the world's outstanding sailplane, would take more space than available. This report should serve to familiarize American glider pilots and designers with its outstanding features.

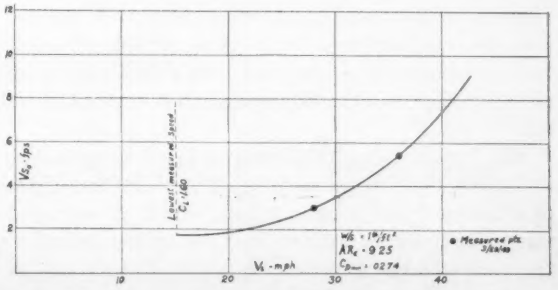

FIG. 1. Velocity polar for turkey buzzard (Cathartes Aura).

Detailed study of this, the world's highest performance sailplane, should prevent wasteful duplication of effort by the sailplane designer. It is hoped that our technological schools will see in the D 30, a product of the Darmstadt school, a way of motivating the engineering aviation courses with live material.

Wolfgang B. Klemperer, Douglas Aircraft, followed with his report on the OSTIV Meeting in Paris, May 3–7, in which he participated. OSTIV stands for the French equivalent of "International Scientific and Technical Organization for Soaring Flight" of the Fedération Aéronautique Internationale. The aims of the OSTIV are: (1) conduct of research in the fields of soaring flight and sailplane development; (2) publication of the research work; (3) compilation of a scientific and technical library and illustrative material; (4) compilation of flight statistics; (5) exchange of information; (6) an OSTIV Congress every year at the international soaring contest of the F.A.I.

Most of the papers dealt with some particular scientific or technical subject. The papers presented were: "Tow Hooks" by Barge and "Flutter Calculus" by Gout, both of the French Air Arsenal. A paper by Lecolazet on "Atmospheric Electricity" described how sailplanes were used in the measurement program. The past, present, and future contributions of the sailplane to the advancement of the arts and sciences of aviation were discussed by Mangeot. A sailplane with auxiliary power in the form of a turbojet was presented by Mauboussin. The advantages of this type of power plant for sailplanes was convincingly portrayed.

Weisshaupt, the Danish delegate, described a Danish expedition into Norway to explore atmospheric wave conditions. The flights were conducted in March, 1948, at Steinfjorden, about 40 miles north of Oslo. A 1949 expedition was still in progress, so the program was in the data-collecting stage. Lambert, a French Golden C pilot, gave a graphic account of his investigations of the cellular nature of thermals. This was followed by a motion picture account of a French sailplane expedition into the Mont Blanc region of the Alps. The paper by Schneider was on the "Problems and Perspectives of the Aerodynamics of the Glider." The theoretical explanation of atmospheric waves over mountainous regions by Lyra and Queney was expounded by Greinel.

The work and progress in the sport and science of soaring in the United States was presented by Klemperer. He described the new sailplane designs, the sailplane performance-testing program of Raspet, the various scientific meetings, the work of Aerophysics Institute in exploration of wind-flow over ridges, and the exploratory flights in the atmospheric waves over California.

The Turkish delegate, Kansu, spoke of the work done in Turkey. Of particular interest were the test flights of a tailless flying wing sailplane, which, if successful, was to be equipped with engines. Cartier reported on the elaborate tests conducted by the French Air Arsenal on structural elements made of wood and of mixed wood and metal construction. The Polish representative, Przymanowski, read two papers: one on "Psychology of Single Seater Training" and the other on the success with a canard type of glider. The rest of the OSTIV meeting was devoted to organizational matters.

The chairman of the evening session was August Raspet, of Mississippi State College, to whom the country owes a debt of gratitude for his unselfish devotion to fostering the progress of the art and science of motorless flight, for his influence upon his colleagues to produce new sailplane designs, and for the use of the sailplane as a scientific tool. It was fitting that he headed the evening session devoted to discussing the sources of energy in the air for the sailplane.

Joanne Starr Malkus, of the Illinois Institute of Technology and Woods Hole Oceanographic Institution, presented a vivid, illustrated talk on "Some Effects of Wind on Cumulus Clouds and Thermals." A cloud is not simply an aggregate of droplets, drifting as a coherent body like a balloon, but is rather, a transient dynamic balance between rapid growth and equally rapid destruction. One of the revelations of the research was that cumulus clouds do not move with the speed of the wind. Since the wind velocity increases, usually with height, the horizontal component of an ascending thermal will differ more and more from the upper air velocities, and therefore the cloud will be moving downwind more slowly than its environment. In the less common cases where the upper air velocities are less than that at the surface, the cloud will move downwind faster than the wind itself. The net difference in forward motion, however, is finally determined by the amount of "entrainment" of the air of the environment at each level. Measurements show that the amount of air has doubled or tripled in a thermal that has risen 4,000 ft.

This behavior of the air results in modifications of cloud growth and motion, producing clouds with asymmetrical shapes. Whenever the wind increases in velocity with height, the updrafts are to be found in the central and windward side of the cloud and the downdrafts on the leeward side. There are insufficient observational data of this phenomenon, and the sailplane pilot is called upon to make these observations.

Some thermals appear to have fixed energy sources, such as a patch of sand or heated soil; others somehow carry their source of energy with them as they move along. How this is accomplished is not yet known to meteorologists. Nor is it known whether a liquid cloud must exist within the chimney before it can move its source along. The answers to these questions will help both the meteorologist's understanding of the basic processes of thermal activity and the soaring pilot's increased enjoyment of his sport.

The last paper was given by Joachim Küttner, Air Materiel Command, U.S.A.F., on the "Techniques and Possibilities of Mountain Wave Soaring." Küttner has an unusual background. In addition to being well versed in the theoretical analysis of atmospheric wave

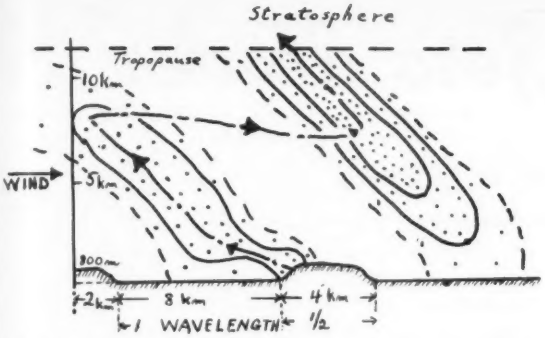

FIG. 2. Wave lift over periodically spaced mountain ridges.

structure, he is an accomplished soaring pilot who has flown in the atmospheric waves.

Küttner summarized the available knowledge on atmospheric waves. In particular, he contributed the latest results from the Prandtl School at Göttingen. There, a computing staff has been determining the atmospheric flow over various configurations of terrestrial obstructions.

In Fig. 2 are shown the results of the theoretical picture for the wave lift over periodically spaced mountain ridges such as exist in the Appalachians and in Nevada. Each ridge adds its impulse to the flow field. Thus, each lift zone progressing downwind becomes stronger and extends higher. It is seen that the second wave already extends to the stratosphere.

A converse field is produced where a valley acts as the wave generator. This valley effect has been the source of many soaring flights at Elmira, N. Y., even though, as yet, there is no authenticated case of wave soaring. However, now that the mathematical existence is proved, it should not be long before soaring flights to high altitudes will be made at Elmira.

Küttner also illustrated waves due to inversions and wind shears. While much less powerful, these waves are nonetheless important in certain turbulence studies. They may also be useful to soaring if they are explored and their anomalous behavior classified.

While most of the paper dealt with mathematical theory, Küttner did present some interesting experimental data from early flights in Germany to prove the structure of the waves. In one case he illustrated a technique wherein a low performance glider was able to outclimb a sailplane just by flying into the wind until the wave was encountered.

Thus far, atmospheric waves have been used by sailplanists only to gain high altitudes. The extensive nature of the waves over the Rocky Mountains should soon be appreciated by an enterprising soaring pilot. The international distance record is sure to fall.

The very fact that the waves extend to such high altitudes makes the exploration and analysis of this powerful natural phenomenon difficult. The French are developing a pressurized-cockpit high-altitude sailplane in the hope of learning more about waves. However, there is still much to be learned of waves between 20,000 and 40,000 ft. which can be done with current sailplanes.

This second joint session of the Institute of the Aeronautical Sciences and the Soaring Society of America was well attended by some 150 persons. Their enthusiastic participation in the program presented reflected not only the widespread interest existing in the scientific aspects of motorless flight but also the fact that technical papers have a concrete contribution to make to the better enjoyment of the art and science of soaring.

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Plan Now to Attend

Thirteenth Wright Brothers Lecture

Washington, D.C., December 17, 1949

The Sperry Zero Reader*

S. KELLOGG† AND C. F. FRAGOLA‡
Sperry Gyroscope Company

(I) Introduction

THE ZERO READER is a new and revolutionary type of flight instrument. Although designed particularly for aircraft use, its principle is adaptable for simplification of the manual control of many complex mechanisms. By appropriately combining data from basic flight and navigational instruments in its Control Unit, it reduces the most complex simultaneous demands of attitude, altitude, heading, navigational, and instrument-landing requirements to a net demand of simply maintaining attitude. In other words, it is a synthesizer.

By separating the "Plan of Flight" from the "Mechanism of Flight," flying with the Zero Reader consists of once setting the plan and then following it by merely making indicated attitude changes as dictated by instantaneous deflections of the Zero Reader Indicator. With previous instrumentation, it was necessary for the pilot to refer continuously the instrument indications to his "Plan of Flight" mentally and, as a result of this comparison, decide upon the control movements.

As indicated in Fig. 1, the Zero Reader consists of a source of gyro stabilization in the form of a vertical gyro for pitch and roll signals and a stabilized compass for yaw or heading signals. To this source is added various control functions, such as altitude and radio beam signals. These signals are carefully combined so that roll, heading, and radio beam (V.H.F., O.D.R., or localizer) control the vertical pointer, while pitch, altitude, and glide path control the horizontal pointer of the indicator.

This combination results from the following considerations: The problem of controlling an airplane, when analyzed from the servomechanism point of view, indicates that the control, if required to be sensitive enough, will lead to hunting. This condition is particularly outstanding when instrument landing is considered, because, as the landing point is approached, the beam becomes narrower—increasing control sensitivity that causes hunting.

To increase the performance, derivative control has been added. If localizer signal is considered to be displacement, then bearing angle to the beam (as derived from the stabilized heading) is a measure of the rate of change of beam signal. Since roll determines the rate of turn, or rate of change of bearing angle in this case, it is its derivative. This establishes that radio beam is the displacement, bearing angle is its first derivative, and roll is its second derivative.

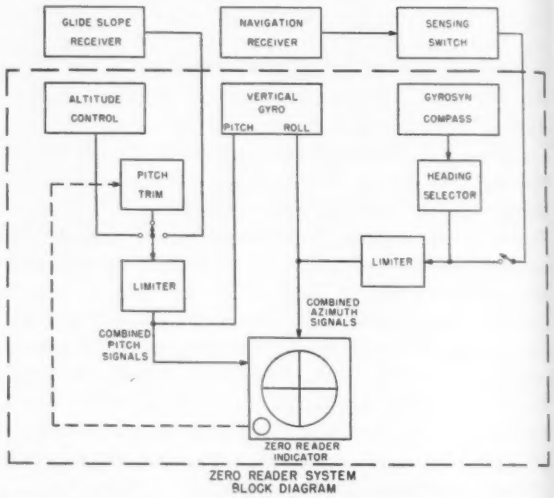

FIG. 1. Block diagram of the Sperry Zero Reader system.

In the case of glide path, beam signal is the displacement, with pitch attitude the first derivative. A second derivative has not been found necessary here. A detailed description of how this is accomplished will be developed in a later section.

(II) History of Combined Indication for Aircraft Instruments

The urgent requirement to simplify aircraft instrumentation for the pilot has been recognized since instruments came into use. The many varied attempts at the solution of this problem may be classified into two broad approaches:

(A) To indicate more and more explicitly the instantaneous demand of magnitude and direction of aircraft control movements.

(B) To combine skillfully the indications of two or more instruments into one unit for simplified, more efficient presentation and utilization. Many inventors have even proceeded beyond this point and have achieved a remarkable similarity to the natural picture that would be viewed from the cockpit under contact conditions.

The fact that combined instrumentation has not fared better in the face of the qualifying test of time

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* Trademark—The Sperry Corporation.

† Engineering Department Head for Flight Instruments.

‡ Engineering Section Head for Electronic Development.

inspires inquiry as to the cause. It is the authors' observation that, up to the present time, the previous efforts did not solve the fundamental problem. The ingenious arrangements of indications made by many inventors, while demonstrating remarkable technical skill, at best only narrowed the scanning circle traveled by the pilot's eyes. They invariably accomplished this reduction at the expense of increased confusion of indication as the size of the scanning diameter is reduced. The mechanical complexity was also greatly increased. Because they failed to include the correct mutual coupling between roll and azimuth and pitch and altitude which is inherent in the aircraft, they were treating a symptom rather than a cause.

While it can be appreciated as a natural tendency, the authors choose to question the need for flight instrumentation to approach or approximate the contact flight picture. It is a natural inclination to interpret something new in terms of something old and known. However, we should always be aware that this approach can inhibit the advance of a new development.

It seems that in the past we have been implying that contact flight is the standard of perfection to be approached. A little reflection will indicate that this need not be the case; moreover, instrument flight has the potentialities at least of giving more flexibility and greater ease of flying with greater accuracy. This potential has been clouded by the fact that instruments have been subject to misinterpretation and have proved to be relatively complex and burdensome to use. The information that can be obtained by one glance during contact flight requires, at times, reference to a number of instruments followed by a complex correlation and interpretation.

If these difficulties were minimized, it would be possible to approach the performance of contact flight. When this goal has been achieved, it will be found that, with instrument flight, a flexibility never attained with contact flight is available. Instrument flight can be made to follow any complex plan that man is able to beam through the atmosphere more easily than it is now possible to fly cross country under contact conditions. The Zero Reader is a significant approach to this end.

The development of the Zero Reader has shown that the utility of flight instruments can be measured by the degree to which they assist the pilot in achieving his "Plan of Flight." To this end, the rate-measuring instruments gave implicit information. While they gave information that was fundamental to the airplane's flying circumstances, considerable skill was required to translate their information into the "Plan of Flight."

With the rate group, the pilot could not be sure of his heading unless he were flying straight and level and without acceleration. It was difficult for the pilot to achieve and maintain heading and attitude with his aircraft without considerable wandering or hunting—particularly in turbulent air. This was due to the variable and uncontrollable mutual coupling of the magnetic compass with attitude and acceleration and

FIG. 2. The Indicator, the Heading Selector, and the Selector Switch.

also the time delay between control displacement and the interpretation of the instruments. The coupling of turning rate of the aircraft with heading indication forced the pilot to use the procedure of "Timed Turns." Turning to a new heading required that the pilot bank the aircraft to establish a desired rate of turn, which was maintained for a time calculated to give the required heading change. Then the plane would be flown straight and level until the oscillating compass settled, thereby indicating the remaining small heading error that would still have to be corrected.

The advent of "dead beat" or decoupled aircraft instrumentation, as supplied first by the Artificial Horizon and Directional Gyro and later by the Attitude Gyro and the Gyrosyn Compass, simplified this problem because:

(1) Time delay between control displacement and attitude change is far less than in the case of interpreting attitude from the rate instruments.

(2) Heading indication is decoupled from attitude and acceleration.

This milestone has made the problem of maintaining attitude and knowing heading a straightforward task. However, despite the fact that it is necessary to conform to the dictates of both heading and attitude and that heading is affected by roll attitude, the pilot usually finds it expedient to correct separately for simultaneous errors in heading and roll—that is, he would correct first for roll and then distort his attitude to correct the heading error, attempting finally to achieve the correct heading in level attitude.

If the pilot is attempting to maintain a reasonably constant altitude, he must also adjust his pitch according to changes in altitude. Therefore, while the pilot really wants to know if he should nose "up" or "down" or roll "right" or "left," he finds himself ill-advised. His instruments tell him that his attitude is off from a standard that, at this moment, does not really apply because his heading is also off and he has departed from his altitude.

To give the pilot the simple instructions of nose "up" or "down" or roll "right" or "left," attitude indications must be properly correlated to heading and altitude indications. In addition, some form of memory system of heading and altitude must be included. The indicator must also incorporate the correct inherent mutual coupling that exists in the airplane between roll and heading and pitch and altitude.

(III) Description of Present-Day Instrument Flight

In modern instrument flying, the "full panel," as the Air Force terms it, is used. It consists of the rate plus the attitude instruments in the subpanels immediately in front of the pilot and copilot positions, as in a DC-6. The instrument of paramount importance is the attitude instrument. This is used about five times as much as the second most-used instruments, which are the stabilized heading instrument plus the altimeter when in level flight or the air speed indicator during climb or descent.

A right turn is made by banking the plane to the right, as indicated by the attitude instrument. As the proper heading is approached, the bank is smoothly reduced to zero as the new heading is achieved.

Altitude is maintained by holding pitch constant. If a small altitude change is required, pitch is modified slightly and *held* until the altitude is achieved.

For a large altitude increase to be made without disturbing power settings, the nose of the plane is raised and held by reference to the attitude instrument. The air speed drops, the nose gets heavy, and, as the desired altimeter indication is approached, the nose is lowered slowly to permit the air speed to increase. The airplane finally reaches equilibrium at the new level with the original air speed and attitude.

When a radio beam is to be followed, headings are variable. In flying the localizer, a heading is selected which will definitely intersect the beam. Upon entering the beam, a turn is started in anticipation of reaching the beam heading at the "on course" position. A process of "bracketing" results in order to maintain flight along the beam. Each heading change is made by controlling roll attitude.

The glide slope is flown much the same as the altimeter. Pitch bracketing is necessary to keep the glide-slope deviation meter reading zero. This is more difficult than holding altitude at cruising, because the speed of the aircraft is much reduced from cruising. The "mushing" effects with change in air speed are greater than in normal cruising, and, frequently, the power settings of the engines will have to be changed to hold air speed within limits.

(IV) Description of Zero Reader

Fig. 1 is a block schematic of the system.

The Zero Reader consists basically of the following units:

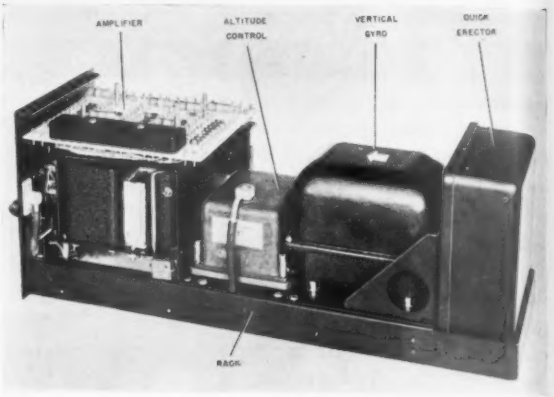


Fig. 3. Zero Reader Control, cover removed.

(*A*) *The Indicator.*—Fig. 2 (*top left*) is a special crossed pointer meter. It consists of two mutually perpendicular indicating pointers that move perpendicular to one another over the face of the indicator. The vertical pointer moves from left to right, while the horizontal one moves up and down. The neutral or "zero" position of this unit is indicated when both pointers are centered. The deflection of the vertical pointer is controlled by the sum of bank, stabilized heading, and localizer so that full-scale deflection is equal to maximum localizer signal, 30° heading departure, or 30° roll displacement. The sum of heading and localizer is limited so that a predetermined maximum bank angle will always cancel it—thus providing that the craft does not exceed the maximum bank permissible. The horizontal pointer is controlled by the sum of pitch and glide slope when on instrument approach or by the sum of pitch and altitude when flying constant altitude. Here again, either glide slope or altitude signal, as the case may be, is limited before adding to pitch—thereby ensuring that the maximum pitch angle is not exceeded. The ratios used are full glide path signal or 300 ft. altitude equals 15° pitch attitude change. In the use of the instrument, the pilot is instructed to concentrate on the intersection of the pointers, rather than on the individual pointers, and then execute control movements, without delay or anticipation, in such a direction that the miniature airplane appears to fly to the intersection.

(*B*) *The Heading Selector.*—Fig. 2 (*top right*) consists of an azimuth repeater driving the pointer plus a concentric heading selector synchro whose rotor is fixed to the parallel-line course setter that is set by rotation of the knob on the lower left-hand corner. Upon selecting a heading, proper control signal is supplied to the indictor.

(*C*) *The Selector Switch.*—Fig. 2 (*bottom*) provides the pilot with a means for selecting the function he wants the Zero Reader to perform. The two knobs on the face consist of the main control-selector knob in the center plus the altitude-control knob to the right. Normally, the two switches are independent, except that an interlock disconnects the altitude control when the main

switch is turned to "approach" position. This is done to avoid a confusion of signals, one calling for constant altitude flight and another calling for a constant rate of descent such as the glide slope would demand in the "approach" position. Within the two sector cutouts, on the face of the switch, are displayed the standard V.H.F. two-course radio-range color patterns so that they, in combination with the arrow above them, eliminate 180° ambiguity in interpreting the notation of the switch positions. For example, if a beam is being followed so that the blue sector on the aeronautical chart is to the left of the path, then the switch is set to the "blue left" position. When in this position, a pattern that agrees with the map notation will appear in the apertures. The little green light in the bottom-left corner indicates when altitude control is off, thus providing assurance to the pilot prior to "take-off."

(*D*) *The Vertical Gyro.*—This has pitch and roll signal pickoffs to supply the attitude repeat-back signals to the indicator.

(*E*) *The Gyrosyn Compass.*—This supplies repeat-back azimuth signals to the indicator.

(*F*) *The Altitude Control.*—This supplies altitude repeat-back signals to the indicator.

(*G*) *The Control* (*Fig. 3*).—This is, at once, the heart and brain of the system, consisting of an amplifier, signal modifier, combiner, and limiter and also includes the vertical gyro and altitude control.

Signals are also obtained from the aircraft's glide slope and navigation receivers.

Operation as a Flight Instrument

When the control switch is set in the "flight-instrument" position, the vertical pointer on the indicator is controlled by signals from roll and azimuth, while the horizontal pointer is controlled by pitch and altitude (if the altitude switch is on). Under these conditions, if the aircraft is flying straight and level and on the heading set by the heading selector at the altitude selected, the indicator would appear as shown in fig. 4—that is, "zero-zero." If the plane is rolled to the left, the vertical pointer will move to the right. If a new heading that is to the right is selected with the heading selector, the vertical pointer will move to the right. Then, in order to achieve that heading, the pilot rolls his aircraft to the right to that bank angle that causes roll repeat-back to return the meter to zero. As he turns, his heading error decreases, causing heading repeat-back to remove the original source of the pointer deflection. He, therefore, has to remove the bank signal to keep the meter zero. By following the pointer with his controls, the pilot will end up "dead beat" on the selected heading with zero roll.

If the aircraft departs from the preselected altitude in a downward direction, the horizontal pointer will move upward—giving a "fly-up" signal (see Fig. 5). As the ship is nosed upward, pitch repeat-back causes the indicator to come to zero. Decreasing altitude error will cause the pointer to deflect downward from zero, calling for decreased pitch. This process continues smoothly until the pilot arrives "dead beat" at the preset altitude with level flight attitude.

Operation as a Radio Navigation Instrument

When the switch is set to the "O.D.R.-LOC.RIGHT" position, a radio beam signal, as selected by the radio navigation equipment, is added to the vertical pointer so that it is now actuated by roll, heading, and radio. The beam heading is set into the heading selector. If the aircraft is flying this heading and the aircraft is to the right of the beam and in level flight, as indicated in Fig. 6, then the pointer will indicate a large "fly left" signal. As the pilot rolls to the left, the pointer will return to zero when the maximum permissible roll angle is achieved. As the plane turns, an increasing heading signal is picked up—moving the pointer to the right of center and indicating to the pilot to take out his roll. This will occur at a controlled rate. When the approach angle is achieved, the plane will be flying straight and level on the approach heading. Under these conditions, the heading signal exactly equals the radio signal. Since the radio signal is constant until the linear portion of the beam is encountered, a constant approach angle is maintained. This continues until the edge of the beam is passed, when the radio signal begins to decrease and causes the pointer to move to the right of center,

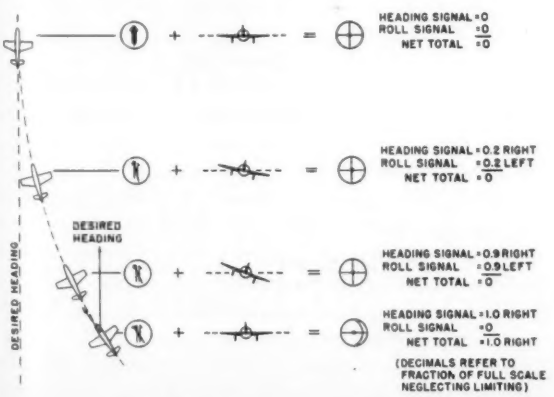


FIG. 4. Turn to a new desired heading.

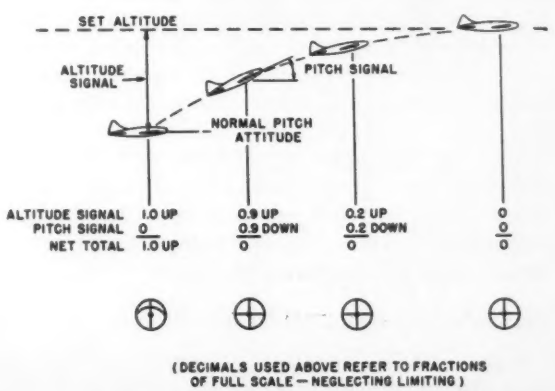

SET ALTITUDE
ALTITUDE SIGNAL
PITCH SIGNAL
NORMAL PITCH ATTITUDE
ALTITUDE SIGNAL 1.0 UP 0.9 UP 0.2 UP 0
PITCH SIGNAL 0 0.9 DOWN 0.2 DOWN 0
NET TOTAL 1.0 UP 0 0 0
(DECIMALS USED ABOVE REFER TO FRACTIONS OF FULL SCALE — NEGLECTING LIMITING)

FIG. 5. Recovery from large altitude error.

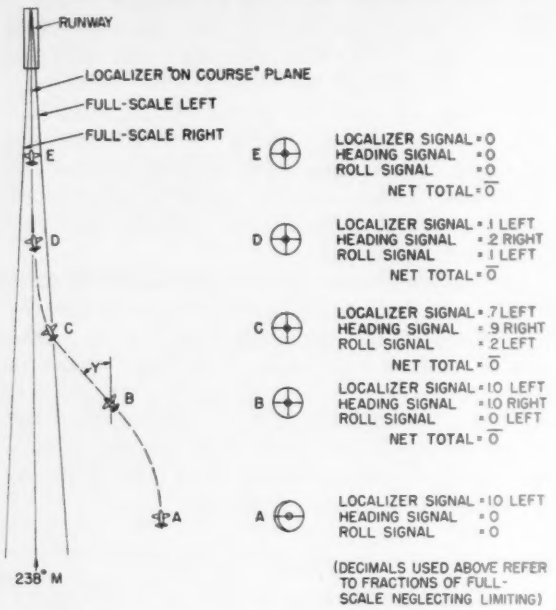


FIG. 6. Sperry Zero Reader seeking the localizer.

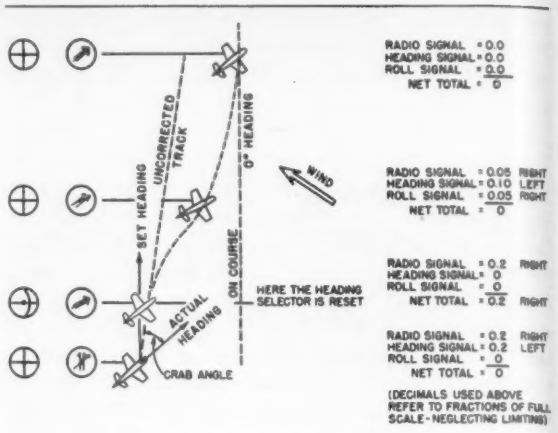

SET HEADING
UNCORRECTED TRACK
0° HEADING
WIND
ON COURSE
HERE THE HEADING SELECTOR IS RESET
ACTUAL HEADING
CRAB ANGLE
RADIO SIGNAL = 0.0
HEADING SIGNAL = 0.0
ROLL SIGNAL = 0.0
NET TOTAL = 0
RADIO SIGNAL = 0.05 RIGHT
HEADING SIGNAL = 0.10 LEFT
ROLL SIGNAL = 0.05 RIGHT
NET TOTAL = 0
RADIO SIGNAL = 0.2 RIGHT
HEADING SIGNAL = 0
ROLL SIGNAL = 0
NET TOTAL = 0.2 RIGHT
RADIO SIGNAL = 0.2 RIGHT
HEADING SIGNAL = 0.2 LEFT
ROLL SIGNAL = 0
NET TOTAL = 0
(DECIMALS USED ABOVE REFER TO FRACTIONS OF FULL SCALE - NEGLECTING LIMITING)

FIG. 7. Correction for cross wind.

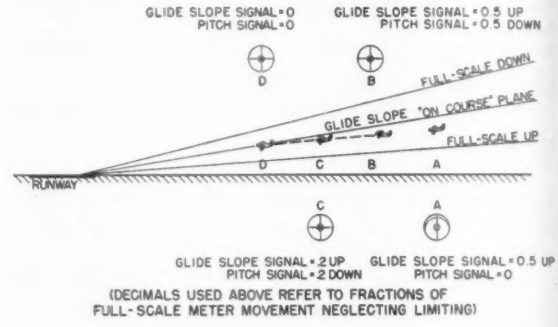


FIG. 8. Sperry Zero Reader seeking the glide slope.

calling for some right roll. As the plane turns, heading signal decreases, requiring less roll. Because of the controlled interdependence of radio, heading, and roll, the plane flies a path that causes the radio signal to decrease to a minimum.

Compensation for Cross Wind

If there is a cross wind, the plane will fly on the downwind side of the beam, with a constant small angular displacement from it (see Fig. 7). The amount is determined by air speed, cross-wind velocity, and the ratio of heading to radio signal. This is caused by the fact that the actual heading does not coincide with the "no-wind" heading, so that, in attempting to maintain the preset heading, the plane will drift to the downwind side of the beam (left in this case), picking up radio signal calling for fly "right" until the heading error equals the wind drift.

A cross wind will be indicated by the departure of the heading pointer from the parallel line selector because of the unique concentric mounting of these two pointers. After allowing time for the airplane's heading to settle while flying a beam, the pilot may adjust the heading selector to agree with his actual heading. In Fig. 7, this process deflects the vertical pointer of the indicator to the right, causing him to roll to the right to erase the deflection. By controlling roll to keep the indicator continually zero, the plane travels along a smooth curve, without hunting or appreciable overshoot, arriving extremely close to the center of the beam.

Operation as a Landing Approach Instrument

When a landing approach is being made, the cross-wind effect is particularly significant. If the cross wind exceeds a certain value, a landing may still be made on the runway by readjusting the heading selector. It was experimentally determined that a ratio of 8 to 1 is a good compromise for heading change versus angular track error. For a 5,000-ft. runway, 150 ft. wide, the permissible error in heading for touch-down on the runway would be 7°. Because of this tolerance, the heading selector should be reset at the middle marker if there is over a 5° heading discrepancy.

When the switch is moved to the approach position, the altitude control automatically goes off and the glide slope radio signal is inserted into the pitch indication. Also, a bias is placed into the pitch signal so that the indicator will show zero at that attitude used for a normal approach on the glide slope.

The recommended procedure for intersecting the glide slope is to fly at constant altitude until the middle of the beam is reached—as indicated by the conventional deviation indicator. At this time the switch is placed at the approach position. If there had been an error in the preset pitch bias, the result would have been a slight displacement from the center of the beam. The optimum ratio of pitch angular change to glide slope angular error was experimentally determined as 20 to 1. A 2° error in pitch setting will cause an error in elevation of 0.1°. At 2 miles from the touch-down point, the actual error would be ±18 ft. The altitude of the glide slope at 2 miles is approximately 450 ft.

	Maximum Error Spread Maintaining Constant Heading and Altitude				Time to Regain Heading and Altitude			
	STD. INST.		ZERO READER		STD. INST.		ZERO READER	
Subject	Degrees	Feet	Degrees	Feet	Time Sec.		Time Sec.	
					Head.	Alt.	Head.	Alt.
1	120	420	3.8	120	Did not regain		35	-
2	70	650	5.5	105	Did not regain		60 35	25 25
3	6.3	160	2.65	55	-		-	-
4	10.5	400	4.2	55	35 No recovery	35	10 20	35 15

TABLE 1—Table of Comparative Flight-Test Results.

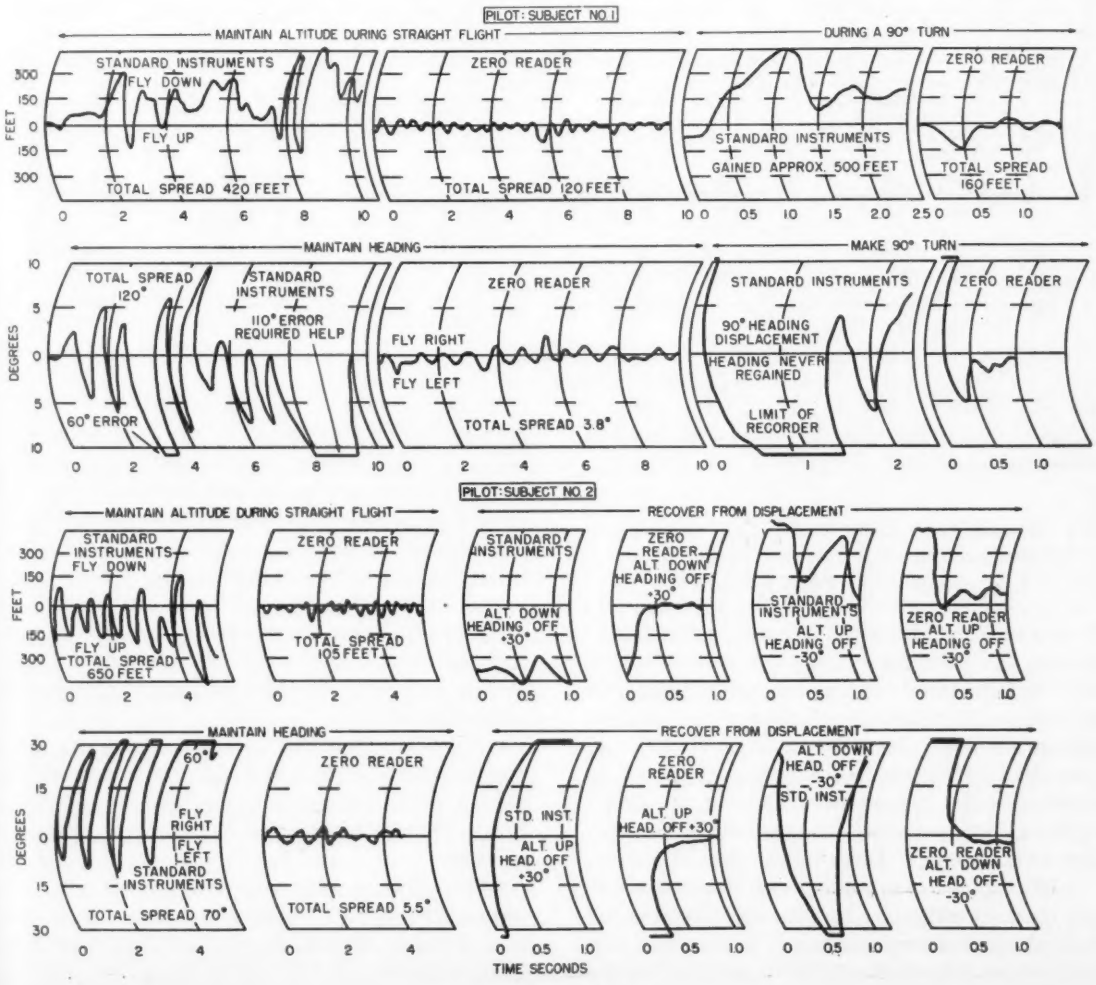


FIG. 9. Flight-test results.

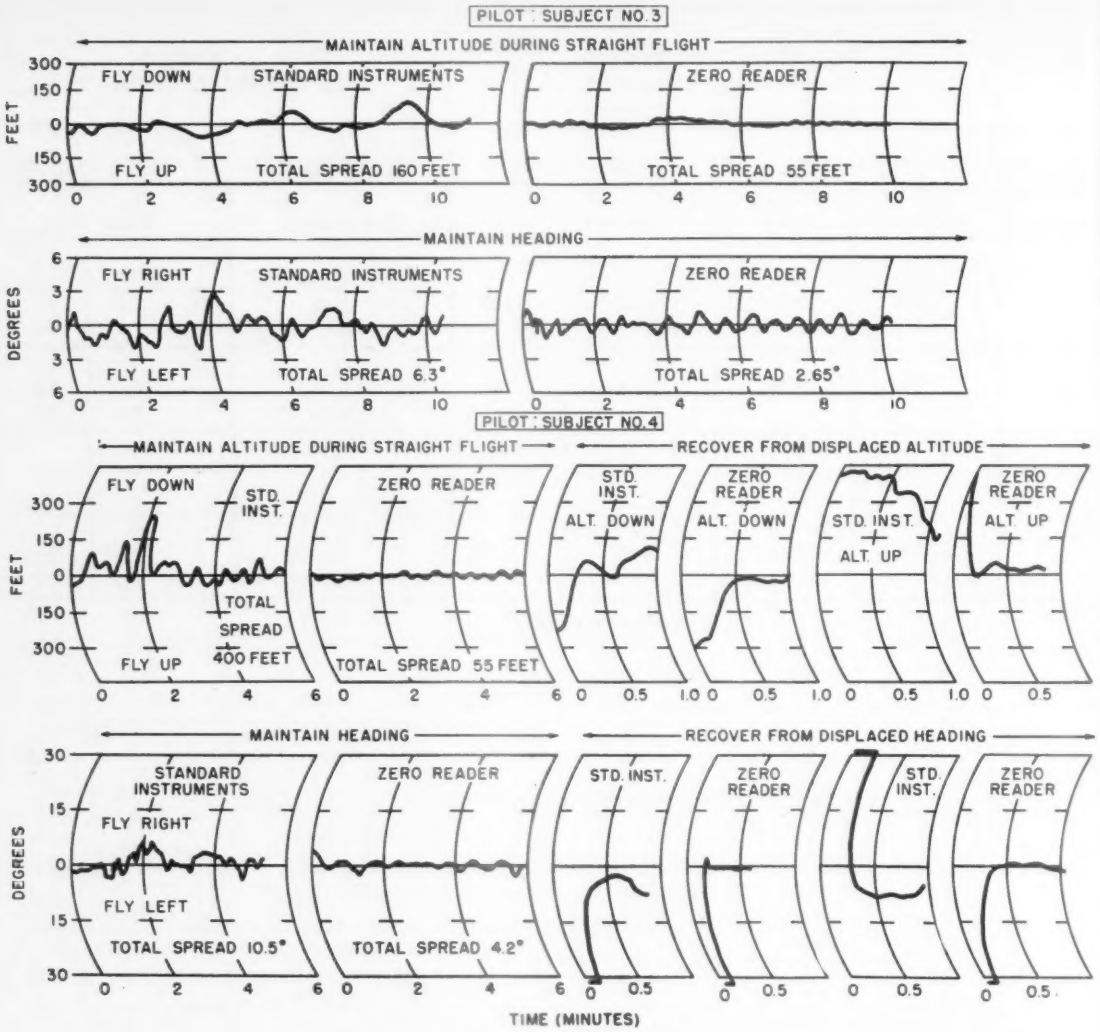


FIG. 10. Flight-test results.

The bracketing of the glide slope is exactly the same as in the case of altitude (see Fig. 8).

(V) Flight Test Results—A Performance Comparison Between Standard Flight Instruments and Zero Reader

All data were recorded in a DC-3 using a "full hood." In general, the following procedure was used in conducting the flight tests. A short instruction period was given to each subject before each phase of the test, and a 5-min. practice period was permitted before the data were recorded. While the recording was in progress, no assistance was given except as noted on the curves. First, the subjects were instructed to maintain constant heading and altitude. Then, in the case of subject No. 1, a 90° turn to a new heading was requested, maintaining constant altitude. For the more experienced subjects, the procedure was altered, and, instead, the altitude was initially displaced 300 ft. and the heading 30°, while the pilot shut his eyes. Then, upon opening his eyes, the pilot was asked to recover as soon as possible, and the recovery patterns were recorded. Unfortunately, at the time of test for subject No. 1, the glide slope was not in operation, and, therefore, these data do not appear. No approach data were taken using standard instruments with subject No. 1 because it was considered to be a hopelessly difficult endeavor.

Subject No. 1 is a female office secretary who has not had any flight experience. This was the second time she was ever in any airplane and the first time in a two-engined craft.

Subject No. 2 has had some Link Trainer experience with the Army at Wright Field, where he works as a civilian project engineer. One-half-hour practice at flying a Fairchild 24 was his only previous piloting experience.

Subject No. 3 is an experienced instrument pilot on two-engined aircraft. He had not done much instrument flying in the last 4 years and had never before flown conventional I.L.S. or Zero Reader.

Subject No. 4 is an instrument pilot. Although he

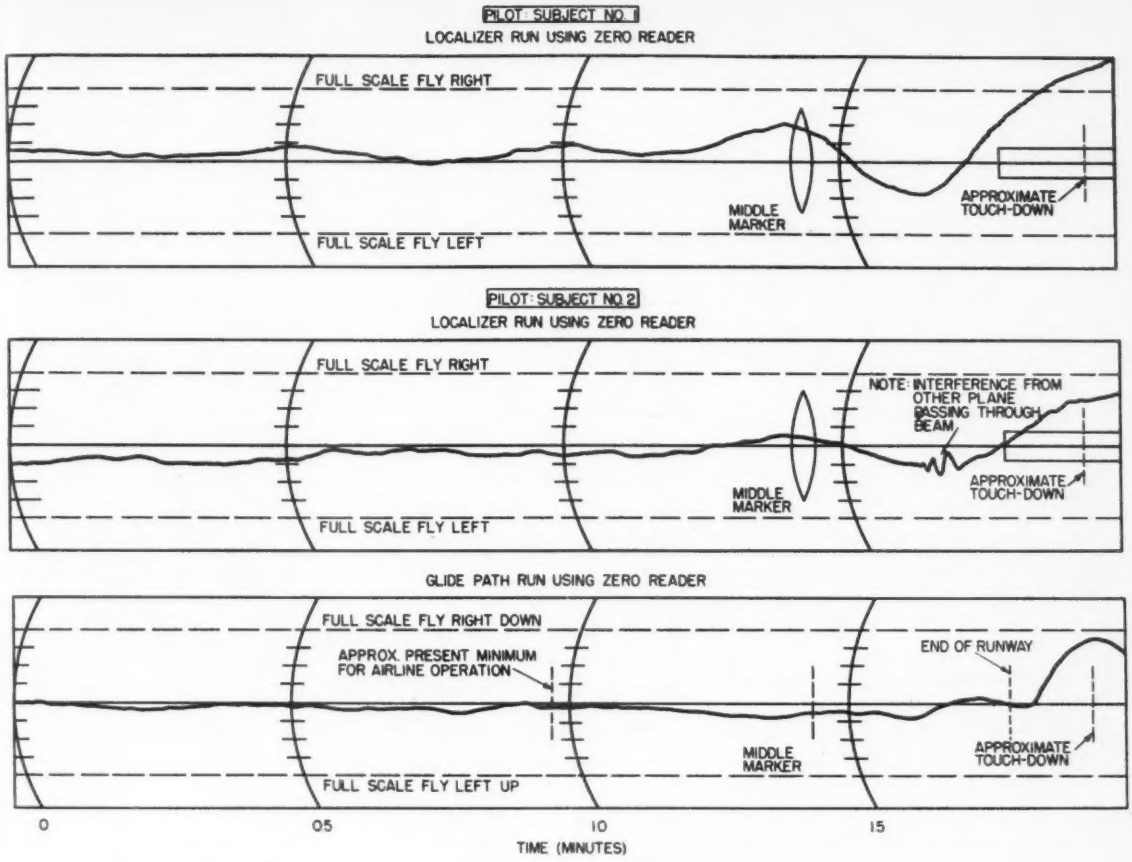


FIG. 11. Flight-test results.

had previously made two approaches on standard I.L.S., he had not made any in the last 2 years and never before flew with the Zero Reader.

Application of Zero Reader

Although the Zero Reader has been treated from the broad approach of a complete flight instrument, it was the urgent need for better instrumentation to simplify the problem of instrument landing which provided the incentive for this development. It is in the solution of this particular problem that the field of application in the near future seems to lie. Automatic Approach was developed and proved before the Zero Reader was developed. Although the Automatic Approach has been providing excellent performance, it is expected that the Zero Reader can serve as a good standby. This should encourage pilots to accept Automatic Approach more readily. To be an effective standby, the Zero Reader should give the pilot confidence that he could *consistently* make manual approaches with it. To serve this function, the Zero Reader has been kept absolutely independent of the Gyropilot or Automatic Approach equipment. In planes equipped with automatic pilots, it has been argued by some that the azimuth, attitude, and altitude signals should be taken "free" from the automatic pilot. However, it was decided that the independent standby feature was so great that it was worth the extra weight and complication of the independent system. Performance comparison records of Automatic Approach with the Sperry A-12 Gyropilot and the Zero Reader are included in Figs. 14 and 15, respectively. The Zero Reader record was made using a pilot who had previous experience with it. The extremes of the plot indicate half-scale meter reading as contrasted to full scale in the previous records.

The use of the Zero Reader is not advocated as a primary flight instrument because it does not give any fundamental data of the aircraft or what it is doing—it only tells the pilot that he is flying "According to Plan." The indicator, in general, indicates neither pitch, roll, heading, altitude, nor departure from the radio beam. For this specific information, the primary instruments, such as the Attitude Gyro, Gyrosyn Compass, Altimeter, and conventional radio deviation indicator, must be relied upon. It is expected that the pilot will occasionally spot-check his standard instruments. The Zero Reader Indicator has warning flags that come into view when the system is not yet ready to operate. This is a precautionary measure to allow tubes to heat and for the Vertical Gyro to erect and come up to speed. When the system is ready to operate, the warning flags disappear from view.

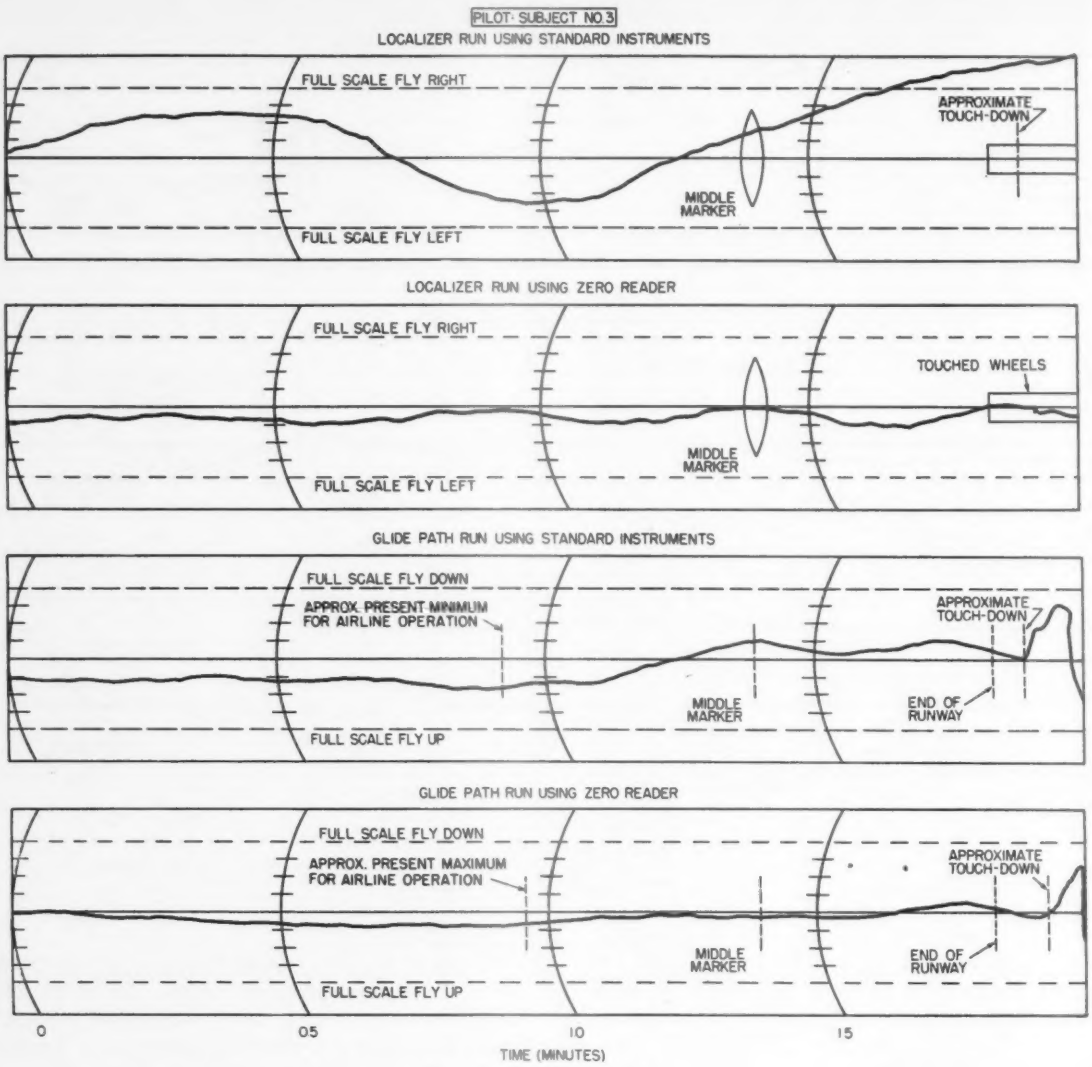


FIG. 12. Flight-test results.

The Zero Reader does serve as a simple and extraordinarily effective complete flight instrument. By separating the "Plan of Flight" from the "Mechanics of Flight" and then, further, by simplifying the "Mechanics of Flight," it enables the pilot to achieve greater accuracy and performance with less expended skill and effort.

This is all accomplished through the means of an ex-

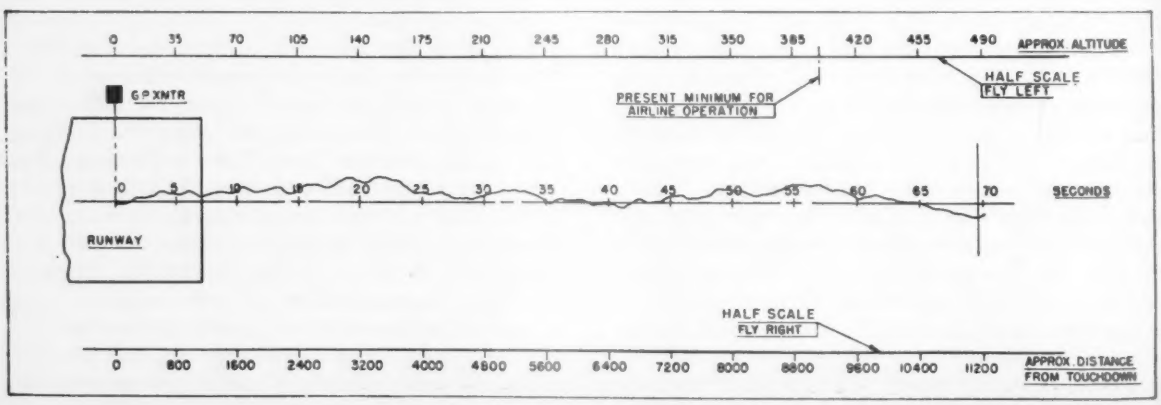


FIG. 14. I.L.S. automatic approach record.

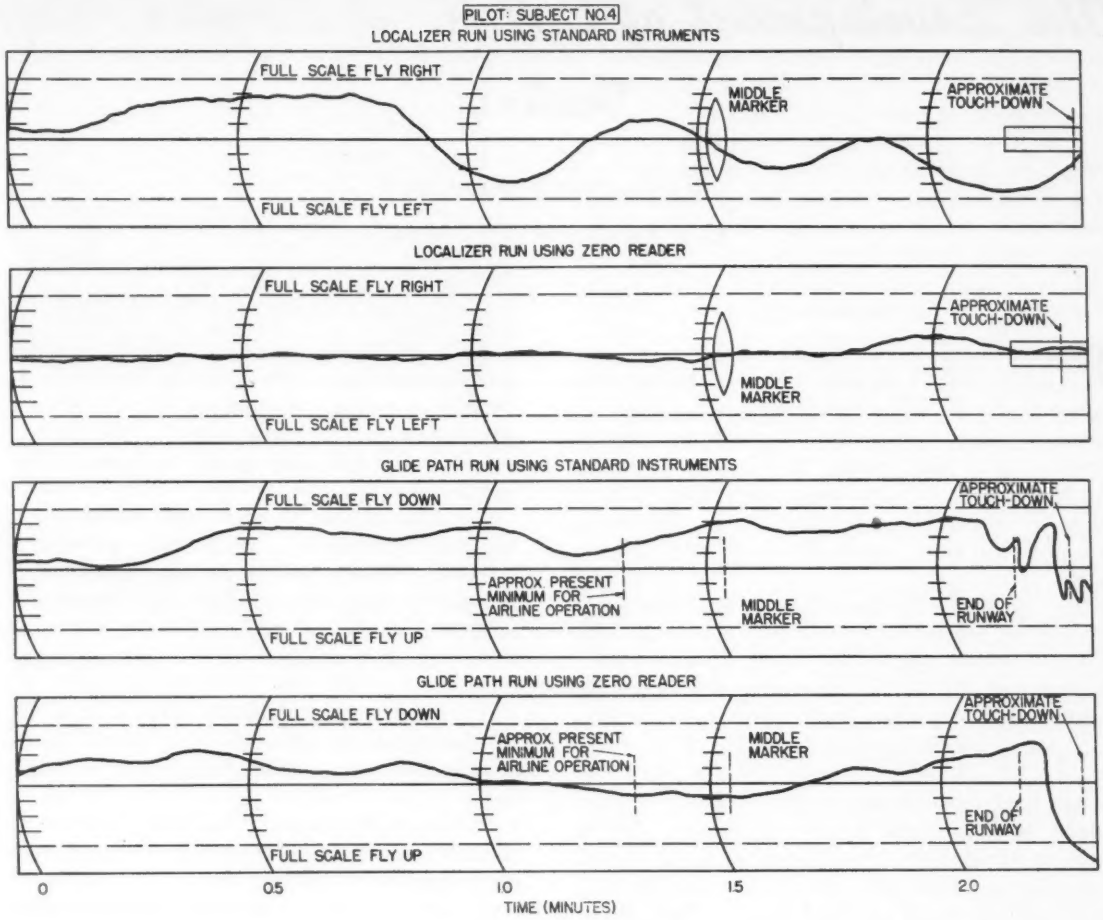


FIG. 13. Flight-test results.

tremely simple indicator. The great simplification of aircraft control which the Zero Reader provides permits the pilot much more freedom to monitor proficiently all other conditions pertinent to safety of flight,

The practical performance of this instrument has been demonstrated by hundreds of flights, which included demonstrations to the U.S. Air Force and most of the commercial air lines. Many of these demonstrations were conducted entirely by the Air Transport Association. As a result, great interest and enthusiasm have developed. This is mainly due to the fact that, in the opinion of experienced pilots who have flown with the Zero Reader, ceilings can be lowered from 400 to 100 ft.

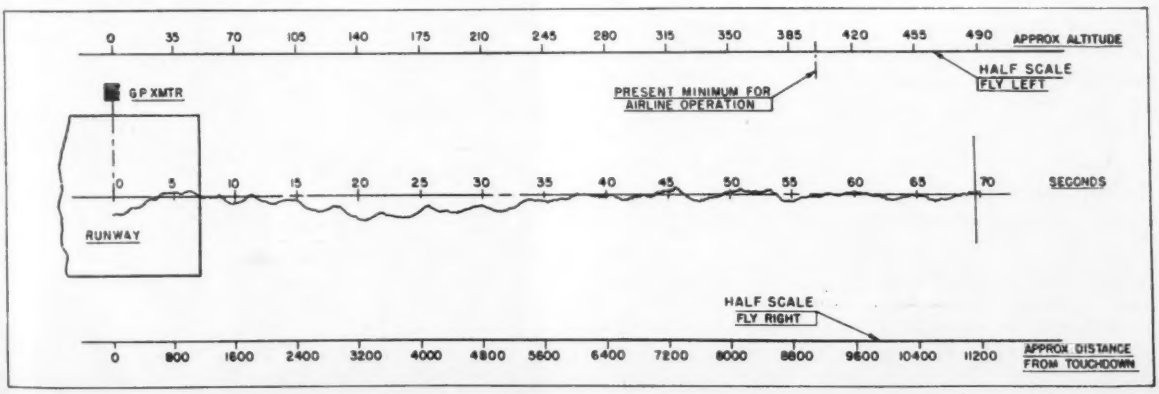


FIG. 15. I.L.S. Zero Reader approach record.

The Development of C.A.A. Helicopter Flight Testing*

RAYMOND B. MALOY†
Civil Aeronautics Administration

Introduction

THIS PAPER HAS BEEN PREPARED with two purposes in mind: first, to provide a historical record of the development of helicopter flight testing techniques, and, second, to present in some detail the flight-test methods currently being used within the C.A.A. It is not intended that this be a treatise on the subject of flight testing, since our test procedures are in a continual state of flux as more knowledge of the subject is acquired.

Although the C.A.A. followed closely the development of theory and experiment in the field of helicopters both from the civil and military standpoint, it was not until the latter part of 1944 that steps were taken to acquire actual practical experience in the operation of helicopters. Arrangements were then made for the loan of a Sikorsky YR-4B helicopter from the Air Forces to conduct basic research and development and to train some of our flight personnel in its operation. In the meantime, through the generosity of the Coast Guard, several C.A.A. agents were permitted to take the helicopter training course at Floyd Bennett Field under Commander Erickson.

The initial experiment conducted with a Sikorsky YR-4B, Serial No. 42-107236, was a program of flight training of several C.A.A. agents with a view toward developing pilot requirements with regard to required hours and specific tests for proficiency.

In the meantime, the helicopter industry was making good progress toward developing civil models for certification. The C.A.A. and the C.A.B. working together had prepared a draft proposal for a set of standards to govern Rotorcraft Airworthiness, and initial discussions were held with the industry in the fall of 1944. The basic philosophy adopted by the C.A.A. and C.A.B. in all these discussions was to keep regulation to a minimum in order not to hamper in any way the development of this infant industry. Consequently, many of the regulations adopted by the C.A.B. were couched in general terms, thus permitting the C.A.A. to develop flexible policies and procedures consistent with the development of the industry.

Condensation of a paper delivered before the Washington Section of the Institute of the Aeronautical Sciences, February 8, 1949.

* Acknowledgment is made of considerable assistance given by J. A. Carran and D. B. Stevenson in the preparation of this paper.

† Chief, Flight Engineering Division.

Developments from YR-4B Tests

As a proving ground for the flight requirements contained in Part 6 of the *Civil Air Regulations*, it was decided to conduct tests on the YR-4B helicopter in our possession. In preparation for the Flight Test Program, the following special instrumentation was prepared and installed:

(*1*) *Stick-Motion Recorder*. As shown in Fig. 1, this device consists of a 30- by 15-in. plywood sheet, hinged at the instrument panel and resting on a pencil clamped to the cyclic stick pointing upwards. Later refinements of this procedure involved use of transparent sheets and a small pin-point of light on the end of the stick.

(*2*) *Fuselage-Angle Indicator*. Mounted on the instrument panel and allowed reading of the longitudinal and lateral disposition of the fuselage with respect to the earth.

(*3*) *Radio Receiver and Transmitter* (*Walkie-Talkie*). Suitable for certain tests requiring communication with the ground or other aircraft.

(*4*) *Accelerometer*. The transmitter was mounted on special brackets, near the rotor shaft.

(*5*) *Airspeed Boom*. This boom (extending 24 ft.

FIG. 1. Stick-position plotting board in recording position in cockpit of Sikorsky YR-4B helicopter.

FIG. 2. Air-speed boom.

from the rotor shaft) was adopted from an N.A.C.A. installation and is shown in Fig. 2.

(6) *Fuselage Angle of Attack Indicator* (Fig. 3). A selsyn transmitting system was available for use with this angle indicator to make the reading of the indicator located at the end of the boom visible on the instrument panel.

(7) *Yaw Angle Indicator.* This was mounted on the boom without selsyn transmission.

In addition, there was the standard installation of temperature gages, etc., common to conventional flight-test installation. This much instrumentation is not required in all C.A.A. helicopter flight tests, since subsequent experience has shown that certain items are not necessary. Experience to date is fairly limited to one or two configurations of the helicopter, and, therefore, because of the widely varied configurations that are making their appearance, special considerations will have to be given to each.

TESTS CONDUCTED ON THE SIKORSKY YR-4B

Air-speed Calibration.—It was anticipated that this item would give considerable trouble because of the difficulty of mounting the pitot head outside the influence of the rotor and also because of the errors that might result from the large yaw angles expected in climbing and gliding flight. The N.A.C.A. had already used a boom installation during their test programs which was copied with certain minor revisions to reduce vibration. The total head tube and the static tube were on opposite sides of the boom and free to move in pitch only. A large circular scale was provided to permit reading the fuselage angle of attack from the cockpit (Fig. 3). A selsyn transmitting system was incorporated with an indicator in the cockpit. The air-speed calibration was first checked over a measured course, and the results of the ship's indicator and the boom indicator were close. These results were later checked by a pacing aircraft. Then a check was made of the boom indicator against the ship's indicator in climbing flight and in autorotation. Below 30 m.p.h., the differences in calibration between level flight and climb or autorotation are great. Nevertheless, calibration from 10 to 30 m.p.h. is considered necessary because of various industrial uses of the helicopter involving level flight in this speed range.

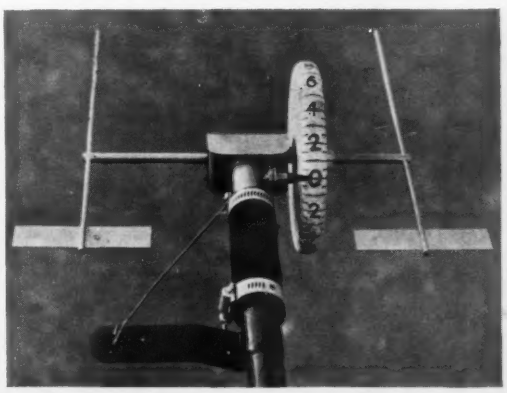
Carbon Monoxide.—The problem of providing adequate ventilation along with adequate protection from CO is not an easy one. Compliance with the requirement of a maximum allowable concentration of 0.005 per cent has now been interpreted to require only hovering into the wind, together with a warning in the manual against protracted hovering tail to the wind.

Ground Handling.—The only special problems involved here are the necessary checks for ground resonance and the determination of the maximum landing and taxiing speed from the standpoint of wheel shimmy and general operational safety. In the case of the YR-4B, the safe taxi speed was definitely limited depending on the smoothness of the take-off surface, since the c.g. was only a short distance aft of the main wheels and any overcontrol or unevenness in the take-off surface would cause the fuselage to rock forward on the nose skids. General maneuverability tests on the ground, involving quick stops and abrupt turns to demonstrate a satisfactory degree of controllability, were considered to be satisfactory substitutes for the wheel brakes. However, subsequent experience indicates the desirability of requiring wheel brakes on all helicopters to take care of power-off landings, particularly on sloping ground.

Autorotational Landing.—The requirement of the ability to make safe autorotative landing is the only specific requirement in the flight section of the present regulations. With the present disc loading of 2 to 3 lbs. per sq. ft., it is desirable to make all autorotational landings with some forward speed rather than attempt to flare to zero air speed before touch-down.

Stick Position and Blade Stall.—In approaching the general problem of stability and control and the effects of c.g. and rotor speed thereon, it was decided to plot stick position, and also obtain some idea of stick vibration from a fatigue standpoint, over a range of the above variables. Figs. 4 and 5 are typical records of stick position. There are several interesting facts

FIG. 3. Fuselage angle-of-attack indicator.



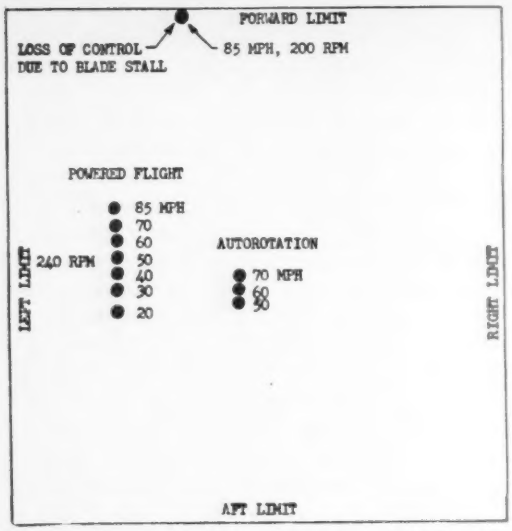
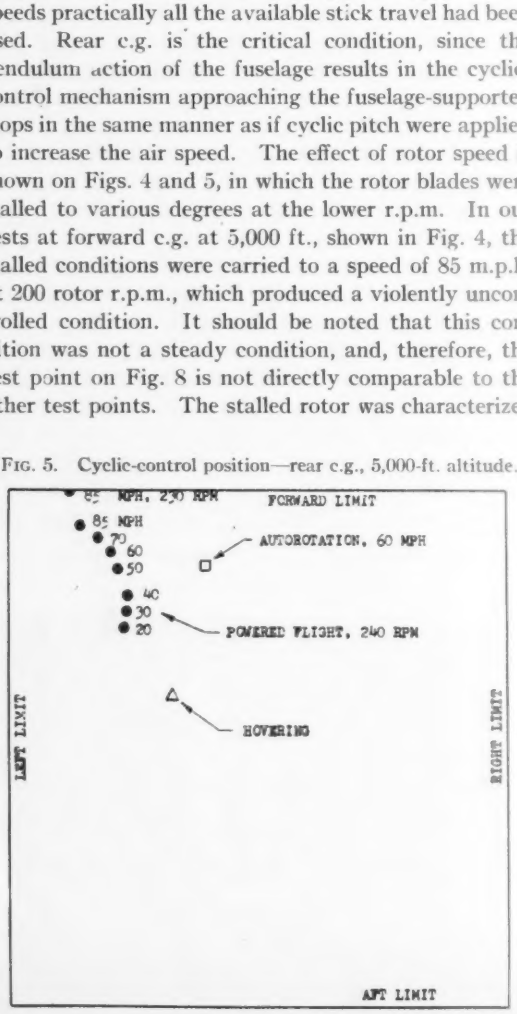


FIG. 4. Cyclic-control position—forward c.g., 5,000-ft. altitude.

brought out by examination of these plots. The stick position is shown to be extremely sensitive to c.g., and it should be noted that at rear c.g. and high forward speeds practically all the available stick travel had been used. Rear c.g. is the critical condition, since the pendulum action of the fuselage results in the cyclic-control mechanism approaching the fuselage-supported stops in the same manner as if cyclic pitch were applied to increase the air speed. The effect of rotor speed is shown on Figs. 4 and 5, in which the rotor blades were stalled to various degrees at the lower r.p.m. In our tests at forward c.g. at 5,000 ft., shown in Fig. 4, the stalled conditions were carried to a speed of 85 m.p.h. at 200 rotor r.p.m., which produced a violently uncontrolled condition. It should be noted that this condition was not a steady condition, and, therefore, the test point on Fig. 8 is not directly comparable to the other test points. The stalled rotor was characterized

FIG. 5. Cyclic-control position—rear c.g., 5,000-ft. altitude.



by severe vibration of the entire helicopter, particularly of the cyclic-pitch control, and a strong positive pitching tendency. Recovery was made from an approximately 85° nose-high attitude with full forward cyclic-pitch control and full right rudder. This action, combined with the drop-off in speed, made recovery possible. It is estimated that roughly 30 to 35 per cent of the rotor disc was stalled. These tests, although not carried to completion, indicated the necessity of carefully establishing c.g. limits and forward-speed and rotor-speed limits to provide adequate margins of control for maneuvering in gusts.

The procedure used to determine the never-exceed speeds, r.p.m.'s, and c.g.'s to preclude encountering conditions just discussed is as follows:

From the stick-position plots at forward c.g., similar to those shown in Figs. 4, 5, and 6, plots of speed versus r.p.m., at which undesirable roughness is indicated, are made for several altitudes. The resulting plot is shown in Fig. 7a. From Fig. 7a, a cross plot of speed versus altitude for maximum permissible r.p.m. is made as shown in Fig. 7b. To prevent operation at speed-r.p.m. combinations where stalling results in roughness, the never-exceed speed was determined by taking 0.9 of the speed at which roughness was encountered at maximum r.p.m. Variation of minimum permissible r.p.m. with altitude is then determined by entering Fig. 7a at the never-exceed speed and selecting the r.p.m. at which roughness occurs for the appropriate altitude. These r.p.m.'s are then plotted against altitude as shown in Fig. 7c.

In cases where limitation on forward stick movement prevents attainment, at rear c.g., of blade stalling on the retreating blade, speed and r.p.m. limits that allow reserve forward stick movement for use in emergency must be established. This was done in one case by drawing a line at constant speed, as per the short dashed line on Fig. 7b, at 0.9 of the maximum obtainable speed with full control deflection. Full control deflection must permit attainment of 1.11 times the never-exceed speed at the highest altitude of the applicable range. With this new speed limitation, it is, of course, then necessary to re-enter the speed-r.p.m. roughness plot, Fig. 7a, to determine the appropriate minimum permissible r.p.m., as shown by the dashed line of Fig. 7c. It is evident that this same procedure also could be used in a case where the permissible r.p.m. range was impracticably small, and it is considered necessary or desirable to extend it with some sacrifice in speed. Adequate controllability margins must, however, still be maintained.

FURTHER DEVELOPMENTS

Performance

Take-off.—To date we have requested the determination of the distance to clear a 50-ft. point at a speed approaching the best rate-of-climb speed. To provide take-off data up to 7,000 ft., altitude take-offs may be simulated at sea level under part-throttle conditions.

The power used at the test altitude for the simulation of any particular density altitude may be obtained roughly from a knowledge of power required for level flight at the test altitude and at the desired climb speed. This power is assumed to give performance equal to that obtained by using take-off power at the ceiling of the rotorcraft. Then, knowing the take-off power setting for sea level and for ceiling, the ground runs (or the complete take-off to 50 ft.) may be made at throttle settings selected from the power curve drawn between those two points. If only the ground-run portions are obtained at various throttle settings, the air-run portions can be pieced on (conservatively, because of ground effect) by using the standard climb data. Corrections for wind, temperature, and density are made in a manner similar to that for conventional aircraft.

Climb.—Climbs at best rate-of-climb speed are obtained and corrected to standard conditions in essentially the same manner as for conventional aircraft. Vertical-climb performance has, however, caused some difficulty. Only slight departures in air speed from zero can result in appreciable reductions in power required for level flight and large percentagewise increases in excess horsepower for climbing.

It has been our desire to obtain plots of density altitude versus time for vertical climbs in the same manner as for airplanes, but to date the difficulty of maintaining horizontal air speed close to zero has often made it necessary to obtain, in flight, the power required to hover, and then, by use of theoretical methods involving estimations of induced power and profile power, vertical-climb rates are calculated. Various methods of assuring vertical flight at $V = 0$ are being developed. One method that the British have used with satisfaction consists simply of weight hung on a long rope suspended beneath the fuselage; bowing of the rope indicates departure from zero air speed.

In addition to the determination of vertical climb rated out of the ground effect, hovering ceiling in the ground effect is obtained to provide pilots with information needed in case vertical take-off is necessary at altitudes above the out-of-ground-effect vertical-climb ceiling. This will allow a pilot to climb a few feet off the ground and then make an acceleration to the best rate-of-climb speed above surfaces unsuited for ground operation.

Landing.—To provide a helicopter pilot with information that will assist him in making a landing in case of power failure, the distance required to land over a 50-ft. obstacle and come to a stop is obtained by use of camera equipment. This distance has been termed the autorotative landing distance. Speed through the 50-ft. point is kept as close to the speed for lowest rate of descent as is compatible with other requirements. For example, consideration must be given to maintenance of rotor energy to permit flaring. Descent rates of the order of 2,000 ft. per min. or more are obtained in autorotation at zero forward speed, dropping off to something of the order of 800 or 900 ft. per min. at the best rate-of-descent speed and then rising again to values of the order of those obtained at zero speed. Correcting the test data to standard conditions is done in the same manner as for airplanes.

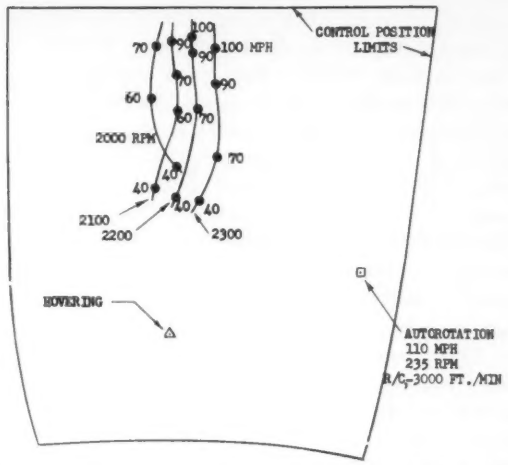
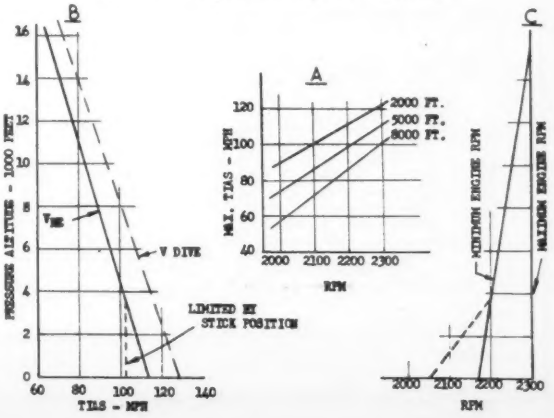


FIG. 6. Cyclic-control position—forward c.g., 5,000-ft. altitude.

Stability and Control.—Lateral control tests have consisted of checking to see that there is sufficient control to produce proper degree of bank in a turn and of preventing uncontrolled rolling during any desired maneuver in pitch. For the conventional single-rotor helicopter with rotor rotation clockwise as seen by the pilot, range of lateral cyclic control must be sufficient to the left to balance the side force produced by the antitorque rotor and to the right to permit straight flight in autorotation where no torque compensation is required. This problem is of no little consequence when laterally asymmetric loadings are considered. An additional longitudinal-control difficulty is also incurred, since a decrease in longitudinal-control range is found as the stick is moved laterally from center. Generally speaking, lateral control power has been no problem; in fact, the lateral control usually appears undesirably sensitive because of the low moment of inertia and low damping about the X-axis. As an indication of the amount of directional control available, we require that the maximum wind, in which a

FIG. 7. Air-speed and r.p.m. limitations.



heading 90° to wind can be maintained, be determined for presentation in the *Rotorcraft Flight Manual.*

Although no stability tests have been set up, it is believed that the art has progressed sufficiently to warrant serious consideration for restricting the amount of stick-fixed undamped, long-period oscillation which is found in forward flight and is similar to the phugoid found in airplanes. During these oscillations in a helicopter, changes in air speed and rotor angle of attack are found. The relation between stick-fixed angle-of-attack stability and stability with respect to speed is fixed in an airplane, since speed and angle of attack are mutually dependent for unaccelerated flight. This does not appear to be true for a helicopter. A stable variation of stick position does not assure desired stick-fixed stability characteristics, because the conventional rotor is unstable with respect to angle of attack even though it may be stable with respect to speed. Some discussion of this problem and its solution can be found in *N.A.C.A. Technical Note No. 1799.* In the case of a gust that increases the rotor angle of attack, the natural instability of a conventional rotor will cause a divergence that may lead to an uncontrolled attitude as the result of the delay in helicopter response to a cyclic control movement. High speed and rear c.g. aggravate this condition, since the cyclic control is already far forward and the least reserve is available to produce nose-down pitch.

A particularly interesting phase of the control problem, at least from the theoretical standpoint, is the condition called the vortex-ring state encountered mainly in vertical descent using part power. In the hovering condition, the flow is downward through the rotor, and, as the descent rate increases, the flow rate down through the rotor decreases. With sufficient increase in descent rate, the flow reverses, and in vertical autorotation it is flowing up through the rotor. At a descent rate of 300 to 600 ft. per min. for present designs, the general flow of air, relative to the descending rotor, is forced outward around the edge of the rotor disc. Some of this air, as it moves above the rotor, is drawn in and downward by the rotor blades. After passing through the disc, it is forced outward, and thus a large doughnut-shaped vortex system is created. Under this condition some loss of control may be encountered. The phenomenon is not well understood, and in some cases uncontrolled nose-down pitching is found which persists until forward speed is attained restoring control. Our investigations include determination of descent speeds and translational speeds at which uncontrollable conditions exist and of techniques useful in recovering with minimum loss of altitude.

In conclusion, it appears that there is a most pressing need for development of handling-qualities standards for helicopters to clarify the goals for the manufacturers and to bring order to our flight-test procedures for stability and control. The helicopter industry, nevertheless, can take great pride in its achievements along these lines during the past several years. It is gratifying to know that the N.A.C.A., as well as the services and individual manufacturers, is working on this problem at the present time.

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197 A New Approach to the Design of Metering Pins in Oleo Struts—R. M. Rosenberg, Associate Professor of Aeronautical Engineering, University of Washington.

204 What the Air Lines Want in Navigation Aids—Ralph S. Damon, President, American Airlines, Inc. Now, President, T.W.A.

205 Military Air Transport Service Specifications and Requirements for Cargo Aircraft—Major R. R. Hajek, Chief of Aircraft Materiel and Equipment Branch, Division of Plans and Operations, M.A.T.S.

206 Evaluation Criteria for Transport Aircraft—L. G. Kelso, R. L. McBrien, Technical Staff, and R. D. Kelly, Superintendent of Technical Development, United Air Lines, Inc.

207 Air-Borne Radar as an Air-Line Navigation Aid—M. G. Beard, Director of Flight Engineering, and R. W. Ayer, Assistant Director of Flight Engineering, American Airlines, Inc.

208 A Simplified Monitoring System for Air-Borne Electronic Devices—W. E. Fensler, Chief, Special Projects Unit, Electronic Analysis Section, Intelligence Department, Air Materiel Command.

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235 A Summary of Flight Load Data Recorded in Tactical and Training Operations During the Period of World War II—Lawrence B. Reynolds, Engineering Division, Air Materiel Command, Wright-Patterson Air Force Base.

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242 The Calculation of Supersonic Downwash, Using Line Vortex Theory—Harold Mirels and Rudolf Haefeli, Lewis Flight Propulsion Laboratory, N.A.C.A.

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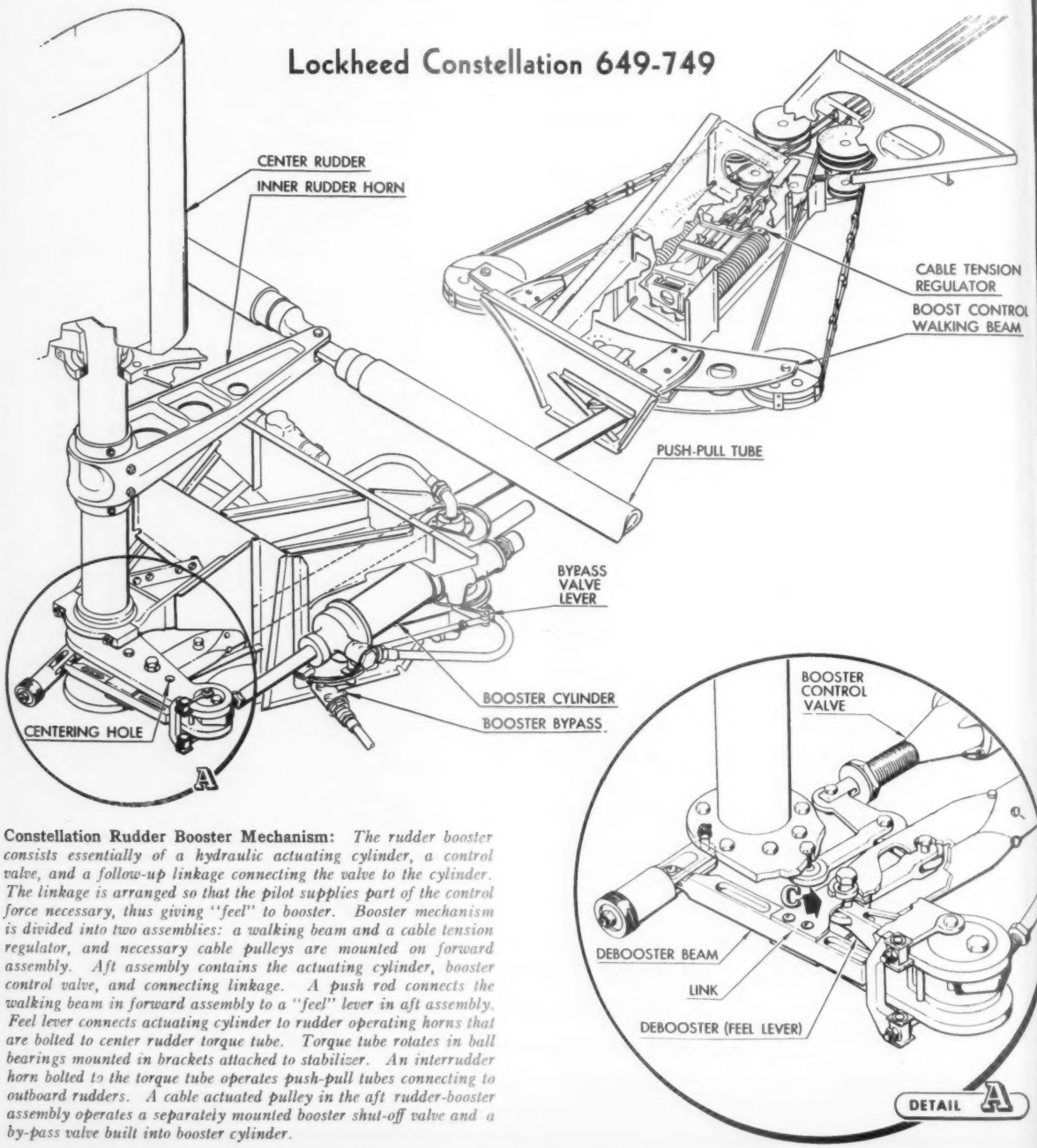
Design Trends

Rudder Control Systems

WITH DEVELOPMENT of large aircraft and high speeds, flight-control problems have increased to the point where manual control no longer can be used alone. Were the problems purely mechanical, the engineering solutions would be relatively simple by means of electrically or hydraulically operated systems. Complicating the whole matter, however, is a human factor, requiring engineers to incorporate "feel" into flight controls so that pilots retain the illusion, if not the actuality, of manual control of flight. Here, two methods, both employing hydraulic boost, are described, showing the Lockheed and Boeing approach.

Lockheed Constellation 649-749



Constellation Rudder Booster Mechanism: *The rudder booster consists essentially of a hydraulic actuating cylinder, a control valve, and a follow-up linkage connecting the valve to the cylinder. The linkage is arranged so that the pilot supplies part of the control force necessary, thus giving "feel" to booster. Booster mechanism is divided into two assemblies: a walking beam and a cable tension regulator, and necessary cable pulleys are mounted on forward assembly. Aft assembly contains the actuating cylinder, booster control valve, and connecting linkage. A push rod connects the walking beam in forward assembly to a "feel" lever in aft assembly. Feel lever connects actuating cylinder to rudder operating horns that are bolted to center rudder torque tube. Torque tube rotates in ball bearings mounted in brackets attached to stabilizer. An interrudder horn bolted to the torque tube operates push-pull tubes connecting to outboard rudders. A cable actuated pulley in the aft rudder-booster assembly operates a separately mounted booster shut-off valve and a by-pass valve built into booster cylinder.*

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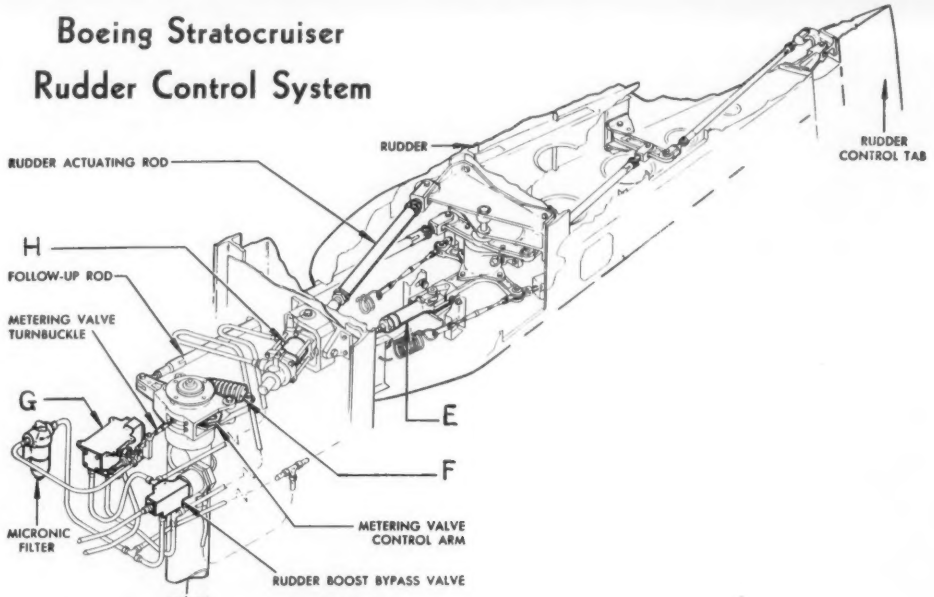
Boeing Stratocruiser
Rudder Control System

Manual Control System: *The integrated hydraulic system of the Stratocruiser is of simple design to insure maximum efficiency and low maintenance time. As in the Constellation, two methods of control are used in the Stratocruiser: the manual system through a trim tab acting as a servo tab, and hydraulic boost. Through the manual system the pilot can handle all normal conditions while the hydraulic boost assists him in maintaining desired directional stability with one or more engines inoperative. In the manual system, the rudder control quadrant (A) is mounted on a beam assembly that consists of two arms to which two parallel "feel" springs (B) are mounted. The springs also are attached to the quadrant by cables (C) but on a smaller diameter and, in effect, preload the rudder cable system. This preload amounts to "feel" at the pilot's and copilot's pedals and is present at all times whether the controls are operating with hydraulic boost or through the tab. In order to permit trim-tab directional correction without at anytime distorting the "feel," Boeing engineers have incorporated the trimtab control into the rudder beam assembly, to which are attached the quadrant and the rudder trim gear box (D).*



Hydraulic Boost: *When the hydraulic boost is on, the manual control tab is locked in neutral by the hydraulically operated tab lock (E). At the same time, the hydraulically operated arm lock (F) disengages, allowing the metering valve (G) to function. Any movement of the rudder pedals then actuates the metering valve, which controls hydraulic pressure to the rudder boost cylinder (H), which in turn moves the rudder. The hydraulic pressure is supplied to the boost unit from the airplane hydraulic system. Rudder boost employs its own accumulator, thus making instantaneous pressure available to the boost system at all times. In emergency, or if manual control is desired, the pilot may shut off the boost system by means of an electrical shutoff valve. A by-pass valve held closed by system pressure will open if the pressure falls below 900 lbs. per sq. in., permitting the fluid to exit freely from the boost cylinder and eliminating fluid drag during manual operation. When by-pass valve is open, the emergency rudder arm lock engages metering-valve lever arm, and the tab lock cylinder releases the tab.*

How to keep a bubble from bursting

HIGH-FLYING planes were having trouble with the seals on their bubble-type canopies. These inflatable rubber seals couldn't take the low temperatures and effects of pressure at high altitudes. They blew out, bursting the bubble at its "seams".

B. F. Goodrich engineers tackled the problem, came up with a new idea for the McDonnell Banshee. They took knitted fabric, rubber-coated inside and out, and cured it to a soft rubber, channel base. Under pressure, this rubberized fabric (slack before inflation) increases the size of the seal many times, with almost *no stretching* of the rubber.

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This new BFG seal has proved so superior that several planes besides the Banshee have adopted it as standard. In each case, it is tailored to the design.

If you have a sealing problem—in canopies, movable walls, wind-tunnel doors or other projects—get the help of B. F. Goodrich engineers now. Write to *The B. F. Goodrich Company, Aeronautical Division, Akron, Ohio.*

B.F.Goodrich

FIRST IN RUBBER

Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

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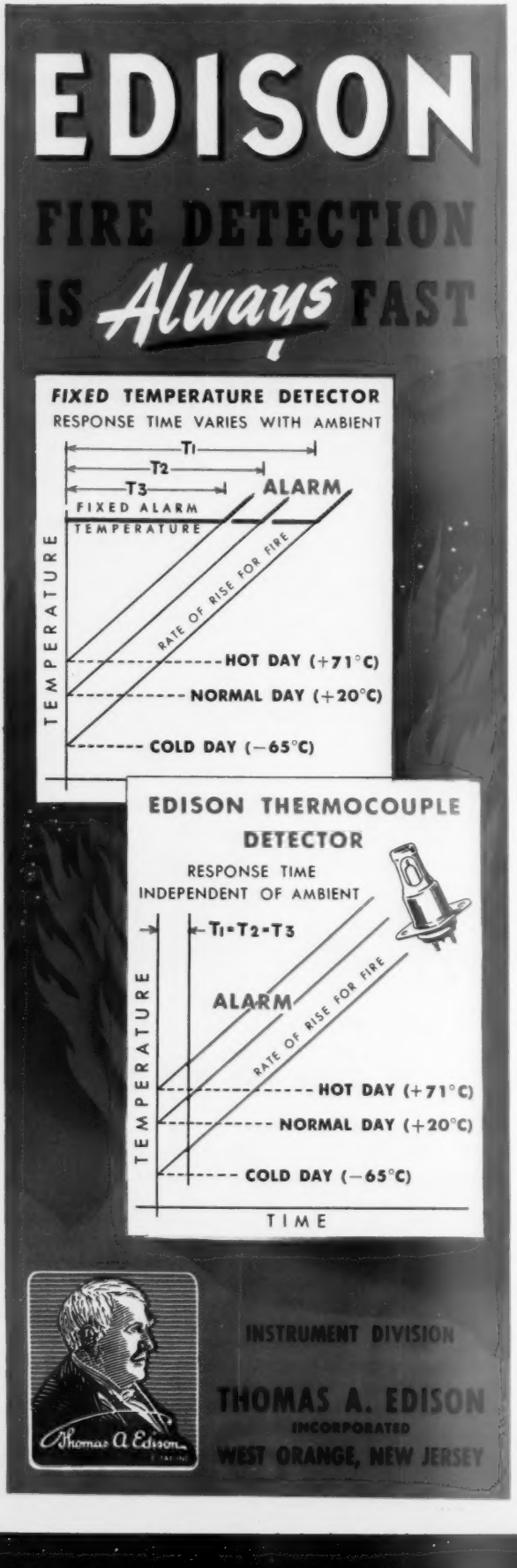

Aerodynamics (2)

AERODYNAMIC LOADS

The Lift Force of a Wing of Finite Span in Supersonic Flow. Falkovich. (*Prikladnaia Matematika i Mekhanika, Vol. 11, 1947, pp. 171–176.*) *U.S., Air Force, Air Materiel Command, Technical Report No. F-TS-1205-1A (GDAM A9-T-23)*, January, 1949, 12 pp., figs. 2 references.

Determination of the lift and drag coefficients of a flat trapezoidal wing in a compressible liquid at supersonic speeds by the application of the acceleration potential in the form of a potential of a double layer, as suggested by Prandtl in his theory of a wing of finite span in an incompressible liquid. Schlicting's attempted use of this method for the solution of the problem of a flat rectangular wing in a compressible liquid at supersonic speed is erroneous because his boundary condition is valid for the subsonic but not the supersonic case. As a special case, the correction of Schlicting's solution is obtained.

BOUNDARY LAYER

Interaction Between Parallel Streams of Subsonic and Supersonic Velocities. H. S. Tsien and M. Finston. *Journal of the Aeronautical Sciences*, Vol. 16, No. 9, September, 1949, pp. 515–528, figs. 6 references.

Analysis of flow fields in cases where a compression wave in the supersonic stream is incident upon the subsonic boundary layer, and where outgoing compression waves are generated by a sudden change in the slope of the solid wall beyond the boundary layer. Both types of disturbances are assumed to be small to permit linearization of the differential equations. The compression disturbance of the shock is propagated upstream from the shock through the subsonic portion of the boundary layer and softening of the shock takes place. Since the distance of upstream propagation is directly proportional to the width of the subsonic layer, there is negligible softening of the shock in cases when the boundary layer is turbulent and the subsonic layer is extremely thin.

FLUID MECHANICS & AERODYNAMIC THEORY

Application of the Computational Treatment of Shock Waves and Vortex Flow to a Body Composed of a Cone and a Cylinder. W. Kai. (*Dresden, Technische Hochschule, Peenemunde Archiv*, 44/15.) *U.S., Air Force, Air Materiel Command, Technical Report No. F-TS-1207-1A (GDAM A9-T-16)*, January, 1949, 32 pp., figs.

Construction of the flow is completed in three steps. The calculation of the flow around the tip follows conical flow theory. The expansion for the left-running Mach waves that arise at the juncture of the conical nose and the cylindrical body are then constructed. Finally, the method of characteristics is used to obtain the larger flow field. Since the shock front emanating from the vertex of the body becomes curved after intersection with the first left-running Mach wave, the entropy jump at the compression shock no longer remains constant. Behind the shock, therefore, the larger flow field is treated as potential flow having vorticity. This vortex flow is treated by a simplifying transformation of the vorticity terms in the characteristic hodograph equations.

Monograph IV; Methods of Linearization in Compressible Flow. II—Hodograph Method. F. E. Ehlers. *U.S., Air Force, Technical Report No. F-TR-1180B-ND*, February, 1948, 255 pp., figs. 63 references.

A survey of the progress in the hodograph method for two-dimensional, irrotational, and compressible flows. Chapter headings include: Hodograph Equations for Incompressible Flows; Hodograph Equations for Compressible Flows; Equations of State of a Perfect Gas; Limit Lines in Compressible Flow; Hodograph Method of Chaplygin; Properties of Hypergeometric Functions; Method of Lighthill for Calculation of Compressible Flows Around Closed Bodies; Method of Tsien and Kuo for Approximating the Upper Critical Mach Number; Hodograph Method Using the Legendre Transformation; Hodograph Method of Bergman; Hodograph Method of Bers and Gelbert Using Σ-Monogenic Functions; Velocity Coefficients for Compressible Flows by Correspondence with Incompressible Flows; Transonic Flows in a Symmetrical Channel; Hodograph Method for the Linearized Equation of State. Most of the special methods are

given in sufficient detail so that the engineer need not refer to the original papers in order to apply them.

Compressibility Effects on Drag. X—Air Drag; Theoretical and Practical Data on Aerodynamic Drag. Sighard F. Hoerner. *U.S., Air Force, Technical Report No. F-TR-1188-1A (ATI No. 43187)*, May, 1949, 93 pp., figs. 67 references.

A comprehensive study of the effect of compressibility on aerodynamic drag which includes the induced, skin-friction, and pressure drag at high subsonic, transonic, and supersonic speeds and their relation to the critical Mach Number in two- and three-dimensional flows. Items in the bibliography that are available through C.A.D.O. are listed with their identification number and security classification.

Two-Dimensional Wing Theory in the Supersonic Range. H. Hönl. *(Göttingen, ZWB, Forschungsbericht Nr. 1903, January 6, 1944.) U.S., N.A.C.A., Technical Memorandum No. 1238*, June, 1949, 34 pp., figs. 6 references.

The plane problem of the vibrating wing in supersonic flow is treated by the method of the acceleration potential. The results are shown to be equivalent to those obtained by Schwarz.

Compressibility Effects in Two-Phase Flow. R. F. Tangren, C. H. Dodge, and H. S. Seifert. *Journal of Applied Physics*, Vol. 20, No. 7, July, 1949, pp. 637–645, figs.

A gas-water mixture, when expanded through a de Laval nozzle, acts as a compressible fluid. A general expression for the flow process in an idealized mixture is developed. The general thermo-hydrodynamic relations for flow through a de Laval nozzle are developed. The magnitude of the velocity of an energy pulse or signal through the mixture is determined and is compared with the velocity of flow. Experimental results are compared with those predicted using the equations developed.

Approximate Method for Predicting Form and Location of Detached Shock Waves Ahead of Plane or Axially Symmetric Bodies. W. E. Moeckel. *U.S., N.A.C.A., Technical Note No. 1921*, July, 1949, 32 pp., figs. 6 references.

A simple form of the continuity equation is applied to the air that crosses the sonic line between a body and its detached shock wave. The assumptions are made that the sonic line is straight and that the portion of the detached wave between its sonic points is adequately represented by an hyperbola asymptotic to the free-stream Mach lines. The method is found to predict shock location to good approximation. The drag of the portion of the body ahead of its sonic points is estimated from the momentum change of the air that crosses the sonic line. The method is also applied to the problem of predicting the relation between shock location and the spillage around the cowl of supersonic inlets.

Experimental Investigation of Moving Pressure Disturbances and Shock Waves and Correlation with One-Dimensional Unsteady-Flow Theory. Paul W. Huber, Cliff E. Fitton, Jr., and F. Delpino. *U.S., N.A.C.A., Technical Note No. 1903*, July, 1949, 65 pp., illus., diagrs., figs. 8 references.

Experimental measurements and theoretical calculations are presented for nonviscous, unsteady-flow phenomena initiated in constant cross-sectional-area passages. The flow considered includes expansion zones, discontinuities in the flow, and reflections and interactions of these quantities. Agreement of experimental pressure-time measurements and Schlieren photographs with theory is very close.

Readers' Forum: On Transient Two-Dimensional Flows at Supersonic Speeds. Charles E. Watkins. *Journal of the Aeronautical Sciences*, Vol. 16, No. 9, September, 1949, pp. 569, 570, figs. 4 references.

On Two-Dimensional Supersonic Flows. Stefan Bergman. *U.S., N.A.C.A., Technical Note No. 1875*, May, 1949, 49 pp., figs. 15 references.

The hodograph method for generating flow patterns of two-dimensional supersonic flows. Two operators generate the patterns from differentiable functions of one real variable. The first operator is obtained by using Riemann's function, the second, by means of the theory of integral operators. The essential feature of this method is that the equations are linear and that the principle of superposition, therefore, holds.

Vychislenie Gidrodinamicheskikh Sil, Deistvuiushchikh na Kavitiruiushchii Kontur v Plosko-Parallel'nom Potoke (Calculation of the Hydrodynamic Forces Acting on a Cavitating Contour in Plane Parallel Flow). D. A. Efros. *U.S.S.R., Akademiia Nauk, Doklady, New Series*, Vol. 60, No. 1, 1948, pp. 29–31, fig. 5 references.

Pressure Distributions Over Bodies of Revolution for Axial Flow. M. Brand. *(Gottingen Aerodynamische Versuchsanstalt, Untersuchungen und Mitteilungen Nr. 3206, December 30, 1944.) U.S., Navy, The David Taylor Model Basin, Translation No. 220*, April, 1947, 49 pp., figs. 2 references.

Experimental Study of Flow Past Turbine Blades. E. Eckert and K. von Vietinghoff-Scheel. *(Deutschen Luftfahrtforschung, Jahrbuch 1942, No. 6, pp. 2–10.) U.S., N.A.C.A., Technical Memorandum No. 1209*, June, 1949, 29 pp., illus., diagrs., figs. 7 references.

Investigation with the Mach-Zehnder interferometer to measure pressure distributions over the turbine blade-grid and the torque exerted by the flow on the rotor in order to find a blade form from which the boundary layer will not separate with high annular spacing ratios.

On the Size of Gas Bubbles and Droplets in Liquids. Siegfried Halberstadt and Paul H. Prausnitz. *(Zeitschrift für angewandte Chemie, Vol. 43, 1930.) U.S., Navy, The David Taylor Model Basin, Translation No. 108*, March, 1943, 19 pp., illus., diagrs., figs. 26 references. (Declassified.)

The Size of Gas Bubbles in Liquids. Robert Schnurmann. *(Zeitschrift für physikalische Chemie, Vol. 143, Nos. 5–6, September, 1929, pp. 456–474.) U.S., Navy, The David Taylor Model Basin, Translation No. 110*, March, 1943, 18 pp., figs. 14 references. (Declassified.)

On the Size of Gas Bubbles in Liquids. Robert Schnurmann. *(Kolloid Zeitschrift, Zeitschrift für wissenschaftliche und technische Kolloidchemie, Vol. 80, No. 2, August, 1937.) U.S., Navy, The David Taylor Model Basin, Translation No. 111*, April, 1943, 6 pp., figs. 8 references. (Declassified.)

Natural Vibration and Damping of Gas Bubbles in Liquids. Erwin Meyer and Konrad Tamm. *(Akustische Zeitschrift, Vol. 4, No. 3, May, 1939.) U.S., Navy, The David Taylor Model Basin, Translation No. 109*, April, 1943, 12 pp., illus., diagr., figs. 3 references. (Declassified.)

Experimental Determination of the Hydrodynamic Increase in Mass in Oscillating Bodies. Rolf Brähmig. *(Schiffbau, Nos. 11, 12, June 1, 15, 1940.) U.S., Navy, The David Taylor Model Basin, Translation No. 118*, November, 1943, 22 pp., diagrs., figs. 34 references. (Declassified.)

The Determination of Pressure in Atmospheric Shock Waves Due to Blasting and the Firing of Guns. Wilhelm Schneider. *(Zeitschrift für das gesamte Schiess- und Sprengstoffwesen, August–December, 1939.) U.S., Navy, The David Taylor Model Basin, Translation No. 102*, April, 1943, 32 pp., diagrs., figs. 9 references. (Declassified.)

INTERNAL FLOW

Hydraulic Analog of Flow Through Supersonic Nozzles. Hilbert V. Schenck, Jr. *American Rocket Society, Journal*, No. 77, June, 1949, pp. 75–78, diagrs. 3 references. Similarities of the flow of water in diverging-converging open nozzles, and the flow of gases through supersonic nozzles.

PARASITIC COMPONENTS & INTERFERENCE

Aerodynamic Properties of Cruciform-Wing and Body Combinations at Subsonic, Transonic, and Supersonic Speeds. John R. Spreiter. *U.S., N.A.C.A., Technical Note No. 1897*, June, 1949, 32 pp., figs. 8 references.

Two theoretical methods for the investigation of the aerodynamic forces and moments exerted on pitched and yawed wing-body combinations that consist of a slender body of revolution and wings in a cruciform arrangement. One method, an extension of the slender wing-body theory of N.A.C.A. T.N. No. 1662, makes possible the determination of simple closed expressions for the load distribution, the forces, and the moments for configurations in which the wings may be of dissimilar plan form. The second method treats combinations of a body of revolution and identical wings of arbitrary aspect ratio and plan form. Results are independent of the Mach Number. It is concluded that the lift and pitching moment are independent of the angle of yaw, and the side-force and yawing moment are independent of the angle of attack. If the vertical and horizontal wings are identical, the rolling moment is zero for all angles of pitch and yaw.

Interference Between Wing and Body at Supersonic Speeds; Note on Wind-Tunnel Results and Addendum to Calculations. Carlo Ferrari. *Journal of the Aeronautical Sciences*, Vol. 16, No. 9, September, 1949, pp. 542–546, figs. 2 references.

A corrected calculation of a numerical example for the pressure distribution on a rectangular wing operating in the upwash from a pointed inclined body of revolution in a supersonic stream. Wind-tunnel results confirm the corrected calculated pressures and show the drastic decrease of lift in the wing-body juncture.

Interference Between Wing and Body at Supersonic Speeds; Analysis by the Method of Characteristics. Carlo Ferrari. *Journal of the Aeronautical Sciences*, Vol. 16, No. 7, July, 1949, pp. 411–434, figs. 7 references.

A theoretical analysis of wing-body interference in a uniform flow field. The body is composed of a conical tip and a series of frustums of cones which extend back to join a cylindrical portion near the wing juncture. The flow over the body is irrotational even in the presence of the shock wave emanating from the nose; the body is axially symmetric and unyawed, although the angle of attack and the wing incidences are arbitrary. The determination of the fluid motion is accomplished by using the hodograph method to derive the field corresponding to the conical nose and by applying the method of characteristics to the remaining regions.

THERMO-AERODYNAMICS

Aerodynamic Heating and Convective Heat Transfer; Summary of Literature Survey. H. A. Johnson and M. W. Rubesin. *American Society of Mechanical Engineers, Transactions*, Vol. 71, No. 5, July, 1949, pp. 447–456, figs. 37 references.

The analytical and experimental information appearing in the literature for convective heat transfer at high velocities particularly emphasizes heat transfer for submerged flow over flat plates, wedges, cones, and cylinders, with a single reference to flow in pipes. The evidence presented supports as a fundamental heat-transfer relation Newton's law of cooling modified to account for the influence of frictional dissipation. A second and very important result is the evidence given to show that the heat-transfer coefficient is independent of the magnitude of the frictional-dissipation term. Data are presented for the recovery factor and heat-transfer coefficient for high-speed subsonic- and supersonic flow velocities. It should be noted, however, that heat transfer by radiation is not considered here as it would be treated in the usual manner for heat transfer without frictional dissipation.

Temperature and Velocity Profiles in the Compressible Laminar Boundary Layer with Arbitrary Distribution of Surface Temperature. R. Chapman and Morris W. Rubesin. *Journal of the Aeronautical Sciences*, Vol. 16, No. 9, September, 1949, pp. 547–565, figs. 16 references.

An analysis of heat-transfer and skin-friction which permits calculations to be made that are accurate to within 5 per cent for flight conditions up to Mach Numbers near 5, and to within 2 per cent under supersonic wind-tunnel conditions up to much higher Mach Numbers. For practical application it is necessary to approximate the surface temperature distribution by a polynomial; then the only unknowns in the final equation are the coefficients of this polynomial. A brief qualitative discussion of the possible effects of the heat transfer on flow separation is given.

Supersonic Convective Heat-Transfer Correlation from Skin-Temperature Measurements on a V-2 Rocket in Flight. W. W. Fischer and R. H. Norris. *American Society of Mechanical Engineers, Transactions*, Vol. 71, No. 5, July, 1949, pp. 457–469, illus., figs. 26 references.

WINGS & AIRFOILS

Method for Calculating Wing Characteristics by Lifting-Line Theory Using Nonlinear Section Lift Data. James C. Sivells and Robert H. Neely. *U.S., N.A.C.A., Report No. 865*, 1947. 19 pp., figs. 11 references. U.S. Govt. Printing Office, Washington. $0.20.

A method is presented for calculating wing characteristics by lifting-line theory using nonlinear section lift data. Material from various sources is combined with some original work into the single complete method described. Multhopp's systems of multipliers are employed to obtain the induced angle of attack directly from the spanwise lift distribution. Equations are developed for obtaining these multipliers for any even number of spanwise stations, and values are tabulated for ten stations along the semi-span for asymmetrical, symmetrical, and antisymmetrical lift distributions. In order to minimize the computing time and to illustrate the procedures involved, simplified computing forms containing detailed examples are given for symmetrical lift distributions. Similar forms for asymmetrical and antisymmetrical lift distributions, although not shown, can be readily constructed in the same manner as those given. The adaptation of the method for use with linear section lift data is also illustrated. This adaptation has been found to require less computing time than most existing methods. The wing characteristics calculated from general nonlinear section lift data have been found to agree much closer with experimental data in the region of maximum lift coefficient than those calculated on the assumption of linear section lift curves. The calculations are subject to the limitations of lifting-line theory and should not be expected to give accurate results for wings of low aspect ratio and large amounts of sweep.

Estimation of the Damping in Roll of Wings Through the Normal Flight Range of Lift Coefficient. Alex Goodman and Glenn H. Adair. *U.S., N.A.C.A., Technical Note No. 1924*, July, 1949, 31 pp., figs. 11 references.

Three methods have been developed for estimating the damping in roll through the normal flight range of lift coefficient for wing plan forms having various sweep angles, aspect ratios, and taper ratios.

Values of the damping in roll calculated by the three methods were compared with experimental values. The most complete method in which all known factors affecting the damping in roll were considered appeared to give the best quantitative agreement with experiment for approximately 60 per cent of the cases investigated. Another method, in which the value of the damping in roll at zero lift coefficient is modified only in accordance with variations in finite-span lift-curve slope, is almost as reliable as the most complete method. The most important factor considered in the analysis therefore appears to be the variation of the finite-span lift-curve slope.

Effect of Aspect Ratio on Undamped Torsional Oscillations of a Thin Rectangular Wing in Supersonic Flow. Charles E. Watkins. *U.S., N.A.C.A., Technical Note No. 1895*, June, 1949, 36 pp., figs. 11 references.

The velocity potential and aerodynamic-torsional-moment coefficients based on the linearized equations of motion for small disturbances are derived for a rectangular wing by means of appropriate distributions of moving sources and doublets. The aerodynamic-torsional-moment coefficient thus derived is combined with a mechanical-damping coefficient to study the effect of aspect ratio on the undamped torsional oscillations of a finite rectangular wing. Decreasing the aspect ratio of the wing is found to have a highly stabilizing effect on the undamped torsional oscillations. The results of some selected calculations are presented in the figures that illustrate this fact.

On the Installation of Jet Engine Nacelles on a Wing. Fourth Partial Report: Pressure-Distribution Measurements on a Sweptback Wing with Jet Engine Nacelle. R. Buschner. (*ZWB, Untersuchungen und Mitteilungen Nr. 3176, November 10, 1944.*) *U.S., N.A.C.A., Technical Memorandum No. 1226*, July, 1949, 45 pp., illus., diagrs., figs. 3 references.

An investigation was conducted in an attempt to develop a sweptback wing-nacelle combination for which the peak pressures are as low as for a sweptback wing alone. The report includes pressure data on a swept wing-nacelle combination with no fillets, with fillets, and with nacelle underslung and supported from a strut. None of these modifications proved successful. An asymmetrical nacelle was designed so that the contour followed the streamline pattern that develops ahead of a sweptback wing. This configuration reduced the peak pressures considerably.

Boundary-Layer and Stalling Characteristics of the NACA 64A006 Airfoil Section. George B. McCullough and Donald E. Gault. *U.S., N.A.C.A., Technical Note No. 1923*, August, 1949, 24 pp., illus., figs. 3 references.

Airfoil Measurements in the DVL High-Speed Wind Tunnel (2.7-Meter Diameter). B. Gothert. (*Lilienthal-Gesellschaft für Luftfahrtforschung, Bericht 156, pp. 5–16.*) *U.S., N.A.C.A., Technical Memorandum 1240*, June, 1949, 30 pp., figs. 7 references.

How Delta-Wing Aids High-Speed Flight; Unconventional Planform Combines Advantages of Low Aspect Ratio and Sweepback, Both Reducing Drag. Robert McLarren. *Aviation Week*, Vol. 51, No. 1, July 4. 1949, pp. 21, 22, 24, 25, illus. 27 references.

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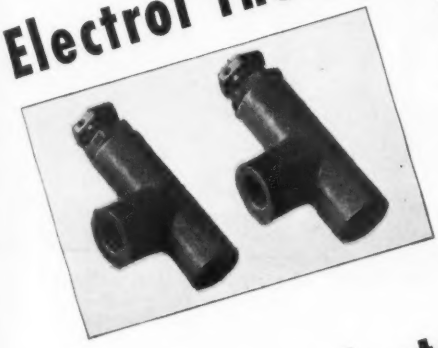

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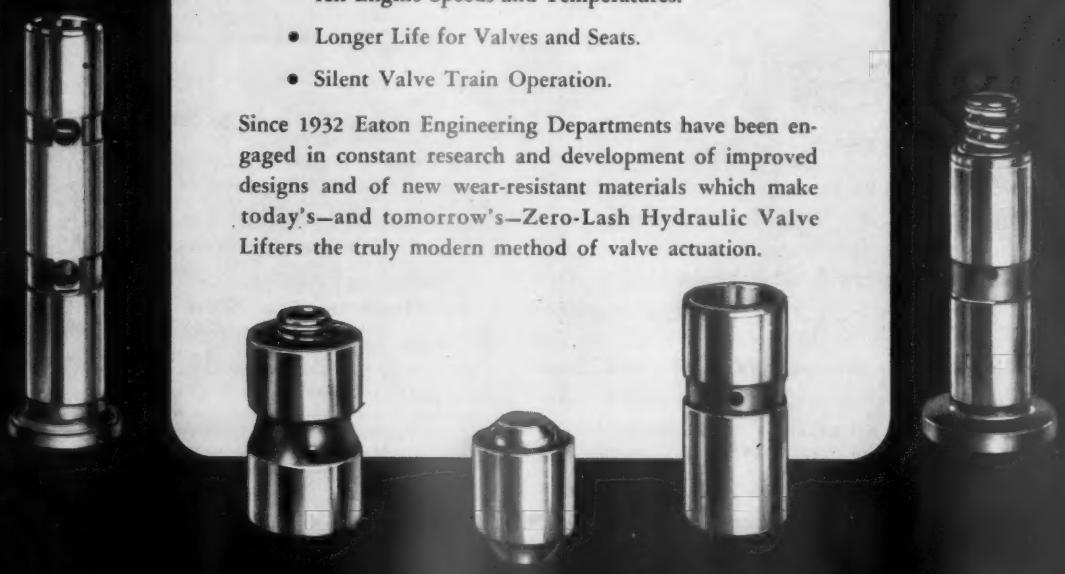

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PRELIMINARY DESIGN

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America's Air Navigation Program; An Appraisal of the Needs and the Benefits. D. W. Rentzel. *U.S., Civil Aeronautics Administration, Statement Before Senate Committee*, April 15, 1949, 26 pp.

CAA Plans $213 Million Airways Program; Three-Year Development Effort Will Fulfill RTCA Interim Phase Outline. Robert Hotz. *Aviation Week*, Vol. 50, No. 26, June 27, 1949, pp. 12, 13.

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GCA—RCAF. Ronald A. Keith. *Canadian Aviation*, Vol. 22, No. 7, July, 1949, pp. 18, 19, 47–49, illus. Description of Ground Controlled Approach at the Royal Canadian Air Force Ground Controlled Approach School, Dorval Airport.

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Physiological Effects of Brief Periods of Exposure to Low Temperatures. Malcolm R. Miller and Albert J. Miller. *Journal of Aviation Medicine*, Vol. 20, No. 3, June, 1949, pp. 179–185, tables.

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Study of Certain Blood Properties in Healthy Men Transferred from a Subtropic to a Subarctic Environment. Albert J. Miller. *Journal of Aviation Medicine*, Vol. 20, No. 3, June, 1949, pp. 201–206, tables.

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Some Physiological Effects Resulting from Added Resistance to Respiration. Clarence C. Cain and Arthur B. Otis. *Journal of Aviation Medicine*, Vol. 20, No. 3, June, 1949, pp. 149–160, figs.

Physical Standards for Air Line Pilots. H. E. Wilson. *The Pilot*, No. 16, July, 1949, pp. 24–26.

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The Role of the Flight Nurse in Air Evacuation. Amalia R. Lazaro. *The Military Surgeon*, Vol. 105, No. 1, July, 1949, pp. 60–64, illus.

The Effect of Instrument Dial Shape on Legibility. Robert B. Sleight. (*Journal of Applied Psychology, Vol. 32, No. 2, April, 1949.*) *U.S., Navy Dept., Office of Naval Research, Special Devices Center, Report No. 166-J-33*, January 5, 1948, pp. 170–188, figs. 30 references. (Reprint.)

Relative legibility of vertical-, horizontal-, open-window-, semicircular-, and round-faced dials. With exposure speed, human subject, and dial type as variables, the tests resulted in significant error variation for dial shape alone. Percentage of error for the open-window dial was 0.5 per cent compared to the second lowest of 10.9 per cent for the round dial.

The Special Devices Used in the Pensacola Pilot Candidate Selection Research Program. Walter R. Mahler. (*The Psychological Corp., Division of Bio-Mechanics.*) *U.S., Office of Naval Research, Special Device Center, Report No. 115-1-10.* 69 pp., figs.

A Method of Increasing the Maneuverability of High Speed Aircraft Within the Limits of Human Tolerance to *g* Forces. J. E. Barmach. (*The Psychological Corp., Division of Bio-Mechanics.*) *U.S., Office of Naval Research, Special Device Center, Report No. 151-1-11.* 68 pp., figs.

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Academic Grades of Students in the Naval School of Pre-Flight. (*Richardson, Bellows, Henry & Co., Inc., Educational Research Project.*) *U.S. Office of Naval Research, Special Device Center, Report No. 383-1-6.* 34 pp., figs.

Construction of Three Measures for Instructor Evaluation. (*Richardson, Bellows, Henry & Co., Inc., Educational Research Project.*) *U.S. Office of Naval Research, Special Devices Center, Report No. 383-1-5.* 47 pp.

Study Skills of Naval Aviation Students; Analysis of the Problem and Recommendations. (*Richardson, Bellows, Henry & Co., Inc., Educational Research Project.*) *U.S. Office of Naval Research, Special Devices Center, Report No. 383-1-4.* 9 pp.

Report on Billet Analysis and Evaluation. (*Richardson, Bellows, Henry & Co., Inc., Educational Research Project.*) *U.S. Office of Naval Research, Special Devices Center, Report No. 383-1-3.* 49 pp.

Amplifying the Instructor Training Program in the Naval Air Basic Training Command. (*Richardson, Bellows, Henry & Co. Inc., Educational Research Project.*) *U.S. Office of Naval Research Special Devices Center, Report No. 383-1-2.* 26 pp.

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A Study of Transfer in a Motor Task with Varying Display-Control Relationships. Robert M. Gagne and Harriet Foster. (*New London, Connecticut College, Naval Medical Research*

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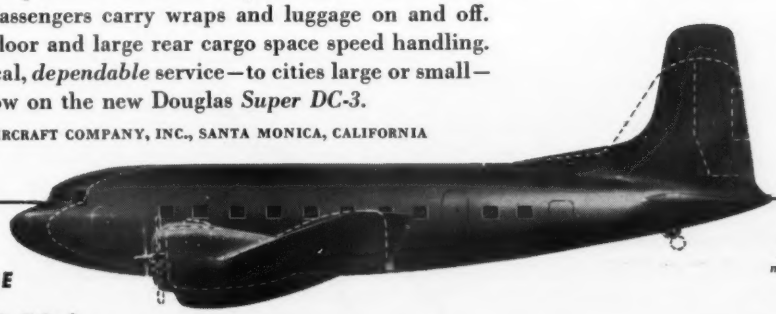

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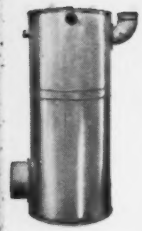

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Laboratory.) U.S., Office of Naval Research, Special Devices Center, Report No. 316-1-3. 29 pp., figs.

Discrete Movements Toward and Away from the Body in the Horizontal Plane. Judson S. Brown, Edward W. Wieben, and Eugenia B. Norris. *(Iowa State University, Dept. of Psychology.) U.S., Office of Naval Research, Special Devices Center, Contract N5ori-57, Project 2, Report No. 6,* September, 1948, 13 pp., figs.

Compilation of experimental data on movements 2.5, 10, and 40 cm. in. length of movement. There is little difference in time between movements toward or away from the body. At lengths much shorter than 40 cm., the accuracy of inward-outward movement is comparable to that for left-right movement. The speed and the length of movement are related by a parabolic function of the form $y = ax^b$.

Positioning Reactions of Uniform Length Executed at Various Distances from the Body. Judson S. Brown and E. B. Knauft. *(Iowa State University, Dept. of Psychology.) U.S., Office of Naval Research, Special Devices Center, Contract N5ori-57, Project No. 2, Report No. 4,* July, 1948, 9 pp., figs.

Compilation of experimental data on the speed and accuracy in the dark of movements of the hand through a fixed distance of 10 cm. The distance from the body at which the movement was executed had no significant effect upon the accuracy of either outward or inward movements.

Characteristics of Discrete Movements in the Horizontal Plane when Executed with One and with Two Hands. Judson S. Brown, Arthur T. Slater-Hammel, and E. A. Bilodeau. *(Iowa, State University, Dept. of Psychology.) U.S., Office of Naval Research, Special Devices Center, Contract No. N5ori-57, Project No. 5, Report No. 5,* August, 1948, 14 pp.

Compilation of experimental data to determine a choice between one- and two-handed control handles. Measurements give reaction time, primary-movement time, total-movement time, secondary-movement time, and accuracy.

Training Manual for Portable Interphone Trainer, Device 8-I. G. L. Draegert, J. C. Kelly, M. W. Buck, and T. D. Hanley. *(Purdue University, Voice Science Laboratory.) U.S., Office of Naval Research, Special Devices Center, Report No. 104-2-12.* 112 pp.

Voice Communication: Effect of Stress Conditions on Speaker Intelligibility. Jane S. Harris. *(Purdue University, Voice Science Laboratory.) U.S., Office of Naval Research, Special Devices Center, Report No. 104-2-10.* 18 pp., tables.

Voice Communication, Effect of Stress on Talkers—A Personality Study. Jane S. Harris. *(Purdue University, Voice Science Laboratory.) U.S., Office of Naval Research, Special Devices Center, Report No. 104-2-11.* 9 pp., tables.

Purdue Speech Intensity Demonstrator, Technical Report. H. W. Nordyke and G. L. Draegert. *(Purdue University, Voice Science Laboratory.) U.S., Office of Naval Research, Special Devices Center, Report No. 104-2-6.* 16 pp., figs.

Voice Communication: Retention of Improved Intelligibility II. T. D. Hanley. *(Purdue University, Voice Science Laboratory.) U.S., Office of Naval Research, Special Devices Center, Report No. 104-2-9.* 18 pp., tables.

Voice Communication: Intelligibility Training with Purdue Speech Intensity Demonstrator. T. D. Hanley. *(Purdue University, Voice Science Laboratory.) U.S., Office of Naval Research, Special Devices Center, Report No. 104-2-8.* 19 pp., figs.

Discrimination of Small Time Intervals Between a Visual and an Auditory Signal. J. W. Gebhard and R. M. Halsey. *(The Johns Hopkins University, Psychological Laboratory, I.C.R.) U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 166-I-60.* 14 pp., figs.

Research and Development of Reading Assessor. Arthur C. Hoffman and Florence E. Gray. *(Tufts College, Institute for Applied Experimental Psychology.) U.S., Office of Naval Research, Special Devices Center, Contract No. N5ori-58, Task Order No. 3, Report No. 1,* 1948, 11 pp.

Experimental determination of the relation of reading speed and eye movements to levels of reading comprehension. There is a positive correlation of comprehension with reading speed. Neither an increased number of eye fixations nor regressive movements appeared to impair comprehension.

Interim Progress Report Laboratory and Road Tests of the Portable Alertness Indicator. John L. Kennedy and Roland C. Travis. *(Tufts College, Institute for Applied Experimental Psychology.) U.S., Office of Naval Research, Special Devices Center, Contract N5ori-58, Report No. 4, Task Order No. 2.* 14 pp.

Description of a first model, and preliminary validation studies by the measurement of the tension levels of an automobile driver and radar trackers.

Ranging Tracking Aiming Point Assessor Device 3-E-7. Robert M. Gottsdanker and John C. Armington. *(Tufts College, Institute for Applied Experimental Psychology.) U.S., Office of Naval Research, Special Devices Center, Contract No. N5ori-58, Task Order No. 1, Report No. 3 (Final Report).* 30 pp.

Experimental determination of basic weaknesses of design and construction which prevented accurate measurements in a variety of problems in the operation of gunsight systems. These problems pertain to the measurement of the accuracy of gun pointing, the determination of training time, and an evaluation of training methods and devices.

Comfortization (23)

An Investigation of Aircraft Heaters. XXXI—Summary of Laboratory Testing of Several Exhaust-Gas and Air Heat Exchangers. L. M. K. Boelter, A. G. Guibert, and others. *U.S., N.A.C.A., Technical Note No. 1455,* July, 1949, 119 pp., illus., diagrs., figs. 29 references.

Experimental comparison of the thermal performance and pressure-drop characteristics of parallel, cross-flow, extended-surface, and all-prime-surface exchangers. Comparison was based upon selected conditions of weight rates and temperatures to which experimental data were adjusted by calculation. Testing techniques are described, and a tabulation made of the measurement of temperature, weight rate, and pressure variables.

An Investigation of Aircraft Heaters. XXXII—Measurement of Thermal Conductivity of Air and of Exhaust Gases Between 50° and 900°F. L. M. K. Boelter and W. H. Sharp. *U.S., N.A.C.A., Technical Note No. 1912,* July, 1949, 39 pp., illus., diagrs., figs. 17 references.

By means of a hot-wire method, the thermal conductivity of air was measured from air temperatures of 50° to 900°F. and the thermal conductivity of gasoline-engine exhaust gases was measured from gas temperatures of 250° to 900°F. The values obtained for air are in good agreement with other data that are available. The values for exhaust gases from an engine operating on fuel-air ratios between 0.056 to 0.085 are practically the same as those for air at the same temperature, but the richer mixtures (fuel-air ratios of 0.10 to 0.15) show increasingly larger values of thermal conductivity, the largest being approximately 30 per cent greater than that of air. The thermal conductivity data obtained are shown in graphs at the end of this report.

ABC's of Combustion Heaters. II—Combustion; Fuel Air Ratios and Contaminating Properties. *Aircraft Heating Digest,* Vol. 1, No. 2, June, 1949, pp. 1, 3, 8, fig.

Chart of Nozzle Ratings, Btu Per Hour. *Aircraft Heating Digest,* Vol. 1, No. 2, June, 1949, p. 6, fig.

The "What If" Board; An Operating Mockup of a Typical Aircraft Heating System with Controls and Component Parts. *Aircraft Heating Digest,* Vol. 1, No. 2, June, 1949, pp. 4, 5, illus., diagrs.

Passenger Seat Design. Douglas O'Neal. *Aero Digest,* Vol. 59, No. 1, July, 1949, pp. 38, 39, 102–104, illus.

Oxygen Converter (N.B.S.) Saves Space, Weight. *Aviation Week,* Vol. 50, No. 24, June 13, 1949, pp. 29, 30, illus.

Education & Training (38)

Training the Brains Trust. Stanley Brogden. *Aircraft,* Vol. 27, No. 8, May, 1949, pp. 17–19, 32, illus. Training in aeronautical engineering offered in Australia at the Technical Colleges of Melbourne and Sidney, and Sidney University.

Copycat Radar Scans 20 Miles in 8 Inches; Sound Waves Bouncing in Water Tank Give Blind-Bomber Trainees Realistic Scope Pictures from Plastic Maps. Andrew R. Boone. *Popular Science Monthly,* Vol. 155, No. 2, August, 1949, pp. 141–145, illus., diagrs.

Push-Botton Instructor; Psychology and a Buzzer Combine to Cut Flight Training Time. Blaine Stubblefield. *Flying,* Vol. 45, No. 1, July, 1949, pp. 42, 73, illus.

For Aeronautical Engineers-to-be. *The Aeroplane,* Vol. 77, No. 1986, July 1, 1949, p. 15, illus. The De Havilland Aeronautical Technical School.

University of Illinois; Institute of Aviation. Leslie A. Bryan. *Shell Aviation News*, No. 128, February, 1949, pp. 10, 11, illus.

Tradesmen for the Industry; Both Airline Operators and Aircraft Manufacturers in Australia Have to Train Their Own Tradesmen. *Aircraft*, Vol. 27, No. 6, March, 1949, pp. 26, 28, 38, illus.

Airline Pilot Training. Stanley Brogden. *Aircraft*, Vol. 27, No. 7, April, 1949, pp. 15–17, 42, illus.

Electronics (3)

The Relative Merits of Presentation of Bearings by Aural-Null and Twin-Channel Cathode-Ray Direction-Finders. S. De Walden and J. C. Swallow. *Institution of Electrical Engineers, (London) Proceedings, Part III, Radio and Communication Engineering*, Vol. 96, No. 42, July, 1949, pp. 307–320, figs. 12 references.

The relative merit of the display of radio bearings and sense by aural-null and twin-channel cathode-ray goniometers has been examined as a function of various characteristics of the signal. The visual method of bearing display has been shown to be superior in nearly all respects except for its relative ineffectiveness in operating at very low signal/noise ratios. It has been shown quantitatively that this disadvantage is slight and could be overcome by a suitable narrowing of the receiver bandwidth. The advantage of the visual method is specially pronounced when the signal received includes an appreciable phase-quadrature component. Similar conclusions have been reached regarding the performance of the associated methods of sense display.

Direction-Finding Site Errors at Very High Frequencies. H. G. Hopkins and F. Horner. *Institution of Electrical Engineers, (London) Proceedings, Part III, Radio and Communication Engineering*, Vol. 96, No. 42, July, 1949, pp. 321–332, Discussion, pp. 340–345, figs.

Measured Impedance of Vertical Antennas Over Finite Ground Planes. A. S. Meier and W. P. Summers. *Institute of Radio Engineers, Proceedings*, Vol. 37, No. 6, June, 1949, pp. 609–616, illus., figs. 5 references.

Notes on the Excitation of Electromagnetic Waves in Cylindrical Metallic Wave Guides. A. Colino. *Journal of Applied Physics*, Vol. 20, No. 6, June, 1949, pp. 576, 577, figs.

Simple formulas are deduced for calculating the amplitude of modes produced in a cylindrical guide when the current's distribution is known. One example is included.

Impedance Measurements in Decimetre Wave Band. Bengt Josephson. (*Kungliga Tekniska Hogskolans, Handlingar Nr. 23 1948.*) *Acta Polytechnica (Stockholm), No. 35 (Electrical Engineering Series, Vol. 2, No. 3), 1949.* 69 pp., figs. 20 references, Sw. Kr. 5.

On the Propagation of Waves in an Inhomogeneous Medium. I. Olof E. H. Rydbeck. (*Chalmers Tekniska Hogskolas, Handlingar Nr. 74, 1948.*) *Acta Polytechnica (Stockholm), No. 38 (Electrical Engineering Series, Vol. 2, No. 5), 1949.* 33 pp., figs., 18 references, Sw. Kr. 3.

The Specification and Measurement of Polarization Errors in Adcock-Type Direction-Finders. W. Ross. *Institution of Electrical Engineers (London) Proceedings, Part III, Radio and Communication Engineering*, Vol. 96, No. 42, July, 1949, pp. 269–277, figs. 9 references.

Scattering of Radio Waves by Metal Wires and Sheets. F. Horner. *Institution of Electrical Engineers, (London) Proceedings, Part III, Radio and Communication Engineering*, Vol. 96, No. 41, May, 1949, pp. 333–340, Discussion, pp. 340–345, figs.

Thermionic Emission from Sintered Cathode of Thoria and Tungsten Mixture. H. Y. Fan. *Journal of Applied Physics*, Vol. 20, No. 7, July, 1949, pp. 682–690, figs.

Theory and Applications of Trochotrons. H. Alfven, L. Lindberg, K. G. Malmfors, T. Wallmark, and E. Astrom. (*Kungliga Tekniska Hogskolans, Handlingar Nr. 22, 1948.*) *Acta Polytechnica (Stockholm), No. 34 (Electrical Engineering Series, Vol. 2, No. 2), 1949.* 106 pp., Sw. Kr. 6.

Tropospheric Effects in Ionosphere-Supported Radio Transmission. Greenleaf W. Pickard and Karlan T. Stetson. *Institute of Radio Engineers, Proceedings*, Vol. 37, No. 6, June, 1949, pp. 596–599, figs. 8 references.

This Baby Fills a Need. *Aircraft*, Vol. 27, No. 7, April, 1949, pp. 18, 44, illus. The V.H.F. transreceiver developed by Amalgamated Wireless (Australasia) Ltd. is housed in a 4-in. cube and with its power plant weighs 9¾ lbs.

Engineering Practices (49)

Programme Design for a High-Speed Automatic Calculating Machine. M. V. Wilkes. *Journal of Scientific Instruments*, Vol. 26, No. 6, June, 1949, pp. 217–220.

Graphic Integrator and Differentiator for Ship Calculations. David L. Evans. (*Werft-Reederei-Haven, Vol. 21, November, 1937*). *U.S., Navy, The David Taylor Model Basin, Translation No. 124*, November, 1942. 6 pp., figs. (Declassified.)

An Electro-Mechanical Device for Solving Non-Linear Differential Equations. Carl A. Ludeke. *American Helicopter*, Vol. 20, No. 6, June, 1949, pp. 600–607, figs.

Nomogram to Determine Parallel Axis Moment of Inertia. Herbert F. Bariffi. *Product Engineering*, Vol. 20, No. 7, July, 1949, pp. 157, 159, figs.

Split Table Adds Third Dimension to Tracings. *Product Engineering*, Vol. 20, No. 7, July, 1949, pp. 97, illus., diagrs. The Perspector drafting machine manufactured by Isometric Projections, Ltd., and distributed by Omerex Precision Products Corp., rotates and foreshortens lines traced by its stylus.

Ellipse-Drawing; Auxiliary Equipment for a Perspective Drawing Instrument. *Aircraft Production*, Vol. 11, No. 129, July 1949, pp. 246, 247, diagrs.

Equipment

ELECTRICAL (16)

Small Power Transformers for Aircraft Electrical Equipments. Langley Morris. *Institution of Electrical Engineers (London), Proceedings, Part III, Radio and Communication Engineering*, Vol. 96, No. 42, July, 1949, pp. 279–291, illus., diagrs., figs.

The paper deals with special types of power transformers for electrical equipments. Climatic and altitude problems are examined in so far as they affect transformers. Transformer design and constructional features are presented with a view to obtaining the smallest possible transformer for a given rating. It is suggested that high-grade magnetic materials should be used for the cores and that high-temperature insulating materials, such as the silicone products, be used to replace organic insulating materials. A design for a 500-VA 1 600-c/s transformer is given in the Appendix.

Speed-Control Methods for Electric Motor Drives. Ferris L. Reed. *Machine Design*, Vol. 21, No. 7, July, 1949, pp. 83–99, illus., figs.

28 Volt DC System; Centralized Control and Protection for Single or Multiple Generator Aircraft. *Jack & Heintz, Aviation Division, Engineering Data, No. 28 V/04159*, June, 1949. 7 pp., illus., diagrs.

S.B.A.C. Identification Scheme for the Standard Wiring System (For Aircraft). *The Technical Instructor*, Vol. 4, No. 5, May, 1949, pp. 10–15, figs.

The Electrical Equipment in the Saab Scandia. Artur Boke. *Saab Sonics*, No. 6, April-June, 1949, pp. 19–24, illus., diagrs.

HYDRAULIC & PNEUMATIC (20)

Sealed Contact Joints in Stationary Machine Parts. Karl Trutnovsky. (*Vereines Deutscher Ingenieure, Zeitschrift, Vol 84, No. 17, April 27, 1940.*) *U.S., Navy, The David Taylor Model Basin, Translation No. 95*, November, 1941. 14 pp., illus., figs. 22 references. (Declassified.)

Big Future for Pneumatics in Aircraft; Hymatic Technical Manager's Views. *Airports & Air Transportation*, Vol. 4, No. 73, July, 1949, pp. 156. (Extended summary of a paper.)

Hydraulic Fitting Standards for Industrial Equipment. F. W. Robinson. *Machine Design*, Vol. 21, No. 7, July, 1949, pp. 133–138, diagrs.

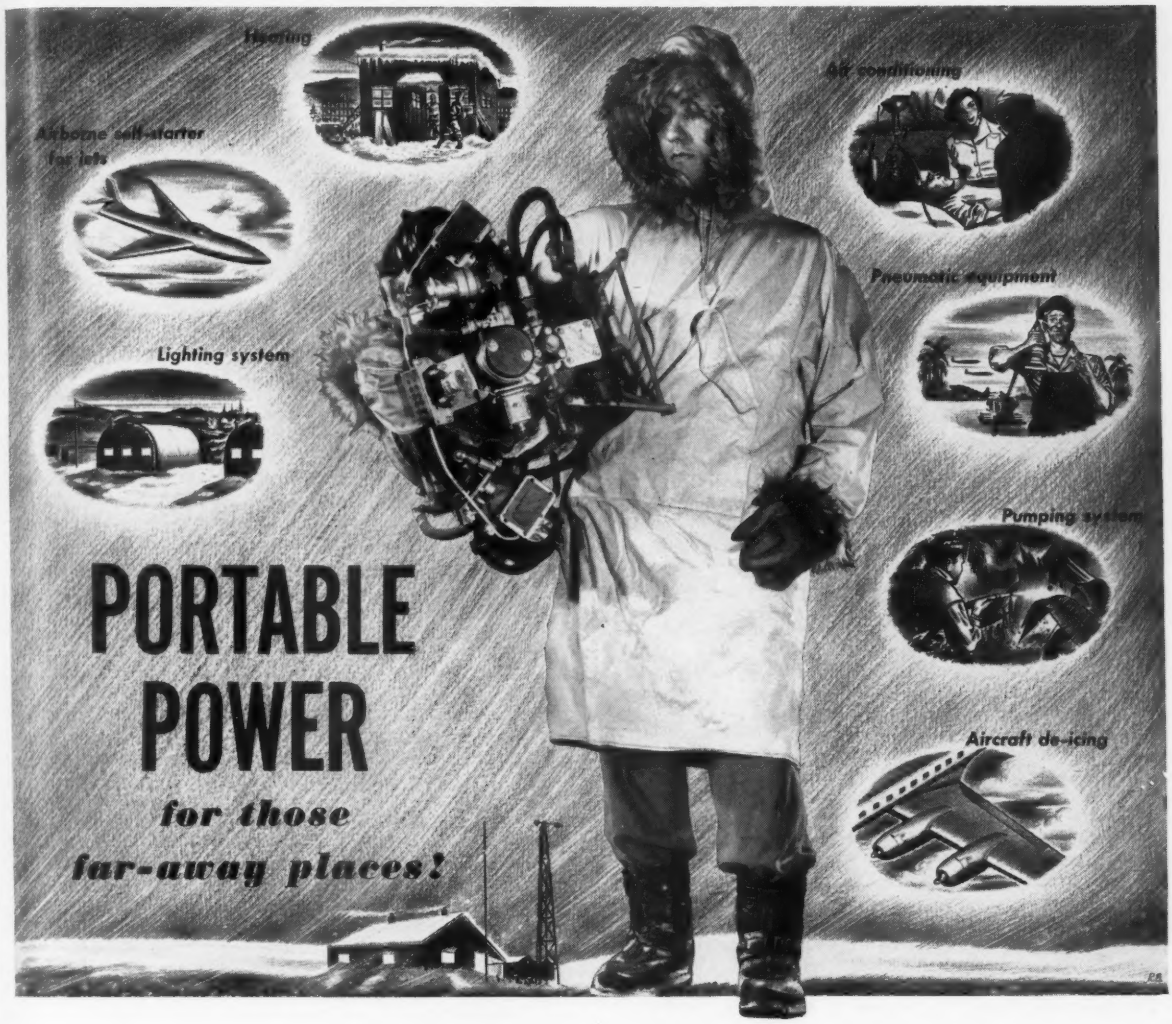
Tube Fittings; Various Designs and Methods of Sealing Available for Fluid Conveying Systems in Machines. *Machine Design*, Vol. 21, No. 7, July, 1949, pp. 106–109, figs.

Developments in High Pressure Hydraulic Systems. H. G. Conway. *Shell Aviation News*, No. 128, February, 1949, pp. 14–18, diagrs., figs.

Flight Operating Problems (31)

HIGH SPEED FLIGHT

Probleme des Hochgeschwindigkeitsfluges (The Problem of



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High-Speed Flight). A. Geiger. *Protar*, Vol. 15, No. 5–6, May-June, 1949, pp. 53–56.

ICE PREVENTION & REMOVAL

Ice Detector. *Aviation Week*, Vol. 51, No. 2, July 11, 1949, p. 21.

NOISE REDUCTION

The Effectiveness of Fillers in Double Walls Against Penetration of Air-Borne Sound. A. Jacobsen. (*Der Bauingenieur, December 5, 1939.*) *U.S., Navy, The David Taylor Model Basin, Translation No. 99*, June, 1942, 10 pp., figs. 6 references. (Declassified.)

PILOTING TECHNIQUE

Thirty-three Handling Reports. R. G. Worcester. *The Aeroplane*, Vol. 76, No. 1983, June 10, 1949, pp. 670–672, illus.

Experimental Flights for Testing of a Reactor as an Expedient for the Termination of Dangerous Spins. P. Höhler and I. von Köppen. (*ZWB, Forshungsbericht Nr. 1027, February 25, 1939.*) *U.S., N.A.C.A., Technical Memorandum No. 1221*, July, 1949, 18 pp., figs. 1 reference.

In the Institute for Flight Mechanics of the DVL a reactor arrangement with a maximum output of 100 kg. was investigated as an expedient for the termination of dangerous spins on an airplane of the FW 56 type. The tests were meant to reproduce the influence of a disturbance of the steady spin condition by a pitching or yawing moment.

The Influence of the Application of Power During Spin Recovery of Multiengined Airplanes. P. Höhler. (*ZWB, Forschungsbericht Nr. 1536, 1942.*) *U.S., N.A.C.A., Technical Memorandum No. 1219*, June, 1949, 7 pp., diagrs. 1 reference.

Flight test of a twin-clockwise-rotating-engined Go 150 airplane to establish an expedient technique for recovery from spin in multiengined aircraft having any combination of direction of engine rotation. For recovery from spins both left and right for any combination of direction of engine rotation, the inboard engines are to be accelerated. In all cases, the outboard engines are idle. With all engines rotating clockwise, recovery is stronger from right than left spins. With all engines rotating counterclockwise, recovery is stronger from left spins. With the combination of clockwise-rotating engines on the right and counterclockwise-rotating engines on the left, recovery is equally good from either direction of spin. With the opposite combination of engine rotation, recovery from either direction of spin is equally poor.

Debate on Relativity. *Flying*, Vol. 45, No. 1, July, 1949, pp. 18, 19, 68–72, illus. Discussion of the relation of the velocity of head and tail air masses to the indicated air speed and the phenomenon of stall.

REFUELING IN FLIGHT

Trans-Atlantic 1953. C. H. Latimer-Needham. *The Pilot*, No. 16, July, 1949, pp. 8–14, figs. Scheduled en route refueling on long-distance commercial air routes will reduce fuel loads and permit either an increased pay load or a reduction of aircraft size for the original pay load.

WEATHER HAZARDS

Air Force Chart Helps in Thunderstorms. *U.S. Air Services*, Vol. 34, No. 6, June, 1949, p. 22, fig. Air-speed limits within which nine types of transport and cargo aircraft may be safely operated.

Flight Safety & Rescue (15)

The Aerodynamic Safety of Civil Aircraft. C. J. O. Moorhouse. *Aeronautics*, Vol. 21, No. 2, July, 1949, pp. 24–27, diagrs.

A survey of requirements recommended by the Air Registration Board in the United Kingdom, with comparable recommendations by the I.C.A.O. for take-off, rate of climb, and landing characteristics; for airworthiness and operations standards, and for temperature accountability.

Those Needless Accidents; Nine out of Every 10 Crashes Result from Showing-Off, Lack of Attention, or Flying in Bad Weather. Harland Wilson. *Flying*, Vol. 45, No. 1, July, 1949, pp. 26, 27, 74.

Fire Safety in the Flight Operation of DC-4 Type Aircraft. Robert R. Houston. *National Fire Protection Assn., Committee on Aviation and Airport Fire Protection, Bulletin No. 36*, June, 1949, 7 pp., diagrs.

Rescued! Jerry Leichter. *The Pegasus*, Vol. 14, No. 1, July, 1949, pp. 6–10, 16, illus. The mission of the Air Force Air Rescue Service and the curriculum of the Pararescue and Survival Training Unit.

Some Ideas for Increasing Air Safety Through Reducing Pilot Loads. I. Albert F. Olsen. *Aviation Operations*, Vol. 11, No. 7, June, 1949, pp. 33, 34, 62.

Is It Safe to Fly? James W. Batchelor. *Skyways*, Vol. 8, No. 7, July, 1949, pp. 14, 15, 44, illus.

How to Cut Crash-Fire Dangers; Inertia Switch that Operates Regular Extinguishing Equipment. Neill G. Bennett. *Aviation Week*, Vol. 50, No. 25, June 20, 1949, pp. 27, 29, 30, illus., diagrs.

Flight Testing (13)

Principles of Flight Testing. VI—Level Speed Determination. *Aircraft*, Vol. 27, No. 9, June, 1949, pp. 20, 40, 41, figs.

Fuels & Lubricants (12)

Many Factors Affect Engine Octane-Number Requirements Harold J. Gibson. *SAE Journal*, Vol. 57, No. 7, July, 1949, pp. 31, 32, diagr. (Extended summary of a paper: Factors Affecting Octane-Number Requirement.)

On Distillates from Fir Stumps. I—Fir Tar and Oils From Fir Tar. II—Neutral Substances Present in Fir Tar and Oils from Fir Tar. Nils Hellstrom. (*Kungliga Tekniska Hogskolans, Handlingar Nr. 21, 1948*) *Acta Polytechnica (Stockholm), No. 33 (Chemistry Including Metallurgy Series, Vol. 1, No. 8), 1949.* 54 pp., tables, Sw. Kr. 3.50.

Octane Numbers and Antiknock Performance; the Meaning of Knock-Testing Methods. *Ethyl News*, August-September, 1949, pp. 3–7, illus., figs.

The Function of Petroleum Research in Aviation. E. L. Bass. *Shell Aviation News*, No. 132, June, 1949, pp. 14–21, diagr., figs.

Antiknock Requirements of Commercial Vehicles. J. A. Edgar, H. J. Gibson, and others. *Ethyl News*, August–September, 1949, pp. 23–27, figs. (Extended summary of a paper.)

Nitromethane Excels as Rocket Propellant. Fritz Zwicky and Chandler C. Ross. *SAE Journal*, Vol. 57, No. 6, June, 1949, pp. 22–24, diagrs. (Extended summary of a paper.)

Nitromethane, a monopropellant that contains all the constituents in the proper ratio for high-explosive heat release. Its performance characteristics are comparable to those of bipropellants and its handling characteristics are superior. It is extremely shock stable, and approaches being an ideally temperature-pressure-insensitive monopropellant.

Organic Solid Rocket Monopropellants. Alfred J. Zaehringer. *Rocketscience*, Vol. 3, No. 2, June, 1949, pp. 32–38, diagrs.

Viscosities and Densities of Lubricating Fluids From −40 to 700 F. C. M. Murphy, J. B. Romans, and W. A. Zisman. *American Society of Mechanical Engineers, Transactions*, Vol. 71, No. 5, July, 1949, pp. 561–574, figs. 30 references.

The viscosities and densities of a large group of high-boiling synthetic and petroleum fluids were investigated over a wide range of temperatures. These were selected because of their promise for use at extreme temperatures or their ability to supply fundamental data for viscometry and lubrication. The variation of density with temperature was practically linear over the range investigated. The A.S.T.M. viscosity-temperature chart, extended from −100° or 700°F. for this work, proved very satisfactory for analysis of the data obtained. Deviations from linearity at the extreme temperatures were studied and classified and nearly all could be explained on the basis of certain physical or chemical transformations shown to occur at the extreme temperatures. The linear portions of the graphs are explained qualitatively in terms of the ability of many types of linear molecules to coil as helices. Convexity at high temperatures is believed general, caused by the disappearance of the helical configuration under conditions of violent thermal agitation.

Observation of the Lubricating Oil Film Between Piston Ring and Cylinder of a Running Engine; The Effects of Lubricant Properties and Additives. R. L. Brooks and M. L. Atkin. *Australia, Council for Scientific and Industrial Research, Aero-*

nautical Research Report ACA-42, September, 1948, 13 pp., illus., figs. 5 references.

Empirical study of the effect of various oils and additives on the lubrication between the top piston ring and cylinder wall of a single cylinder aircraft engine. Only antiwear additives such as tri-cresyl-phosphate and oiliness agents, when used in conjunction with them, showed any effect. It is physical rather than the chemical factors that determine the breakdown of the oil film.

"UCON" Brand Fluids and Lubricants. *Carbide and Carbon Chemicals Corp., Booklet*, 28 pp., illus., figs. 6 references. Physical properties of polyalkylene glycols and their derivatives

A Stability Test for Additive-Motor Oils. *U.S., National Bureau of Standards, Technical Report No. 1359*, July, 1949, 5 pp. 1 reference.

Evaluation of lubricating oils with additives by a controlled simulation of characteristic deposits found on engine cylinder walls. In the apparatus, a controlled oil flow passes over an enclosed steel test strip that can be adjusted in slope and temperature. After a test, residual oil is flushed from the surface with precipitation naphtha. The increase in weight of the test strip is a quantitative measure of the deposit.

The Activities of the Standard Oil Development Company in Relation to Aviation. E. V. Murphree. *Air World*, Vol. 2, No. 1, July, 1949, pp. 7–11, illus.

Oil Weights. W. F. Schaphorst. *Aviation Operations*, Vol. 11, No. 7, June, 1949, p. 44, diagr.

A monogram for converting cubic feet or gallons of fuels and lubricants into pounds, and vice versa. Chart can be used for ordinary and high-grade gasoline, kerosene, fuel, Diesel engine oil, and lubricating oil.

Gliders (35)

A Tailless Research Aircraft; An Account of the Structural Design, Manufacture and Flight Trials of the Tailless Glider of the National Research Council of Canada. W. J. Cox, J. N. Siddall, and T. E. Stephenson. *Aircraft Engineering*, Vol. 21, No. 244, June, 1949, pp. 184–190, illus., diagrs.

Altitude Gliding Over the Alps. I—The Meteorological Requirements and Observations. E. Klochner. *Sailplane and Glider*, Vol. 17, No. 6, June, 1949, p. 128.

Sailplane Weather. B. L. Wiggin. *Weatherwise*, Vol. 2, No. 3, June, 1949, pp. 51–54, illus.

The High-Speed WLM-1. Rene Comte. *Soaring*, Vol. 13, No. 7–8, July-August, 1949, pp. 9, 13, illus., fig.

The Elfe (II, Husch). Alex Dawydoff. *Soaring*, Vol. 13, No. 7–8, July–August, 1949, p. 11, diagrs.

Guided Missiles (1)

The Laws of Motion in Space Travel. Eugen Saenger. *Interavia*, Vol. 4, No. 7, July, 1949, pp. 416–418, diagrs.

Brief exposition of the mathematics for calculating the trajectories of an unpowered earth-satellite spaceship through a point at an altitude of 100 km. The trajectories of different conic sections will depend upon the angle and velocity of departure of the vehicle.

Operational Aspects of Guided Missiles. Howard B. Hudiburg and Richard G. Thomas. *Antiaircraft Journal*, Vol. 92, No. 3, May-June, 1949, pp. 19–21.

Supersonic Guided-Missile Progress. I—Background, and Problems of Guidance & Control. Ralph E. Gibson. *Aero Digest*, Vol. 59, No. 1, July, 1949, pp. 40–44, 104, 105, illus., diagrs.

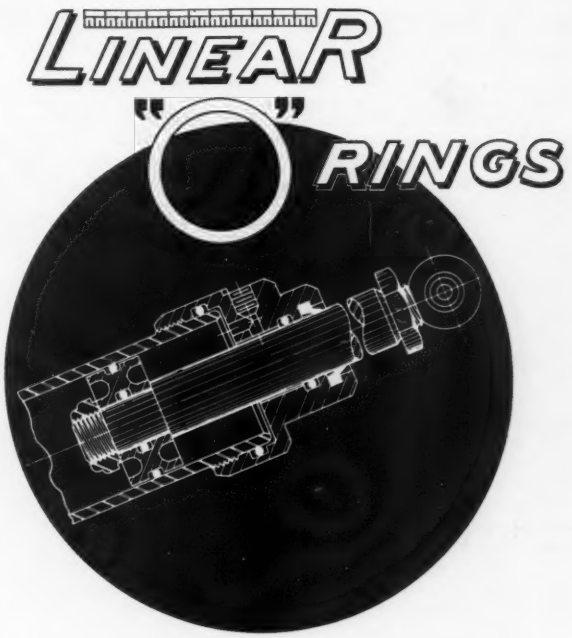
Outline of Guided Missiles. W. L. Richardson. *Ordnance*, Vol. 34, No. 175, July-August, 1949, pp. 43, 44, illus.

Measurement of the Spin of a Projectile in Flight. H. D. Warshaw. *Review of Scientific Instruments*, Vol. 20, No. 7, July, 1949, pp. 507–509, diagrs., figs.

The Flight of Gorgon IV; Ram Jet Powered Missile (Martin) Makes a Test Flight Over the Pacific. *Flying*, Vol. 45, No. 1, July, 1949, pp. 20, 21, illus.

Three and One-Half Times the Speed of Sound; Martin Designs and Fabricates the Vehicle (Viking) which Uses a Rocket Power Plant, Now Being Tested by the Navy. *U.S. Air Services*, Vol. 34, No. 6, June, 1949, p. 8.

Proving the Rockets; Army, Navy, Air Force Operations at White Sands. Philip G. Blackmore. *Ordnance*, Vol. 34, No. 175, July-August, 1949, p. 21, illus.



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3,000-Mile Missile Test Range at Banana River Gets Started. *The Martin Star*, Vol. 8, No. 7, July, 1949, pp. 2, 18, fig.

The Rocket Plane. I. Hermann Oberth. (*Wege zur Raumschiffahrt, Part 4, pp. 271–282.*) Translation by Alfred J. Zaehringer. *Rocketscience*, Vol. 3, No. 2, June, 1949, pp. 28–31, diagrs.

An Elementary Discussion of the Stability of Rocket Missiles at Subsonic and Supersonic Speeds. Donald J. Ritchie. *Rocketscience*, Vol. 3, No. 2, June, 1949, pp. 39–46, diagrs. 3 references.

Instruments

AIRCRAFT (9)

New Accelerometer Will Aid Crash Study; Navy Research Develops Small, Light, Omnidirectional Device as Accessory for Operational Aircraft. Irving Stone. *Aviation Week*, Vol. 50, No. 24, June 13, 1949, pp. 21, 22, illus.

Position Errors of the Service Airspeed Installations of 10 Airplanes. William Gracey. *U.S., N.A.C.A., Technical Note No. 1892*, June, 1949, 48 pp., illus., diagrs., figs. 10 references.

Flight calibration of the variation of static-pressure error with engine power and flap setting in representative flight conditions. The installation included static-pressure vents on the nose and rear section of the fuselage and pitot-static tubes mounted on the wing, the vertical tail, and the nose of the fuselage. Static pressure-error for static vents on the rear section of the fuselage remained approximately constant with angle of attack and became negative with flap deflection. The static-pressure error for the wing, fuselage-nose, and vertical-tail installations became more negative with increasing angle of attack and more positive with flap deflection; the effect of engine power for these installations followed no consistent trend.

Electrical Pickoffs for Pilotless Aircraft Instruments. Jack Andersen. *American Society of Mechanical Engineers, Paper No. 49-SA-13*, June, 1949, 11 pp., diagrs. (Preprint.)

A brief description and comparison of electrical pickoffs that are used for automatic flight control and for telemetering flight information to a ground observer. Types of pickoff included are the contact, strain gage, variable reluctance, potentiometer, "E," synchro, capacitive, thermoelectric, and photoelectric devices. Choice among them is influenced by aircraft size and performance and the system of telemetering employed. The evaluation of each type as to its adaptability to a.c. or d.c., required signal, output power, relative size and weight, and its resolution, reliability, accuracy, ruggedness, and approximate cost is tabulated.

Instrument Overhaul Shop. Joseph Albin. *Aviation Operations*, Vol. 11, No. 7, June, 1949, pp. 28, 29, illus., figs.

TEST & MEASURING

Devise Panel-Type Accelerometer. *Aviation Week*, Vol. 51, No. 5, August 1, 1949, p. 27.

A Contribution to the Methods of Optical Distance Measuring; Specially with Regard to the Problems of Automatic Plotting. Arne Bjerhammar. (*Ingeniorsvetenskapsakademiens, Handlingar Nr. 202, 1949.*) *Acta Polytechnica (Stockholm), No. 42 (Mechanical Engineering Series, Vol. 1, No. 8, 1949)*, 141 pp., figs., Sw. Kr. 15.

An automatic plotting tachometer that employs two complete objectives each of which may be focused, even though the angle between their axes be altered, and which permits double image observation of a fixed base at a large tachometric angle.

The Resonance Method of Measuring the Ratio of the Specific Heats of a Gas, C_p/C_v. V—A: An Improved Apparatus for Measuring the Ratio of the Specific Heats of a Gas. B: The Use of Electronic Counter Circuits to Measure Low Frequencies and a Variable Low Frequency Oscillator. L. Katz, S. B. Woods, and W. F. Leverton. *Canadian Journal of Research, Section A Physical Sciences*, Vol. 27, No. 3, May, 1949, pp. 27–38, diagrs. 12 references.

The Resonance Method of Measuring the Ratio of the Specific Heats of a Gas, C_p/C_v. VI—Carbon Dioxide, Nitrous Oxide, and Methane. L. Katz, W. F. Leverton, and S. B. Woods. *Canadian Journal of Research, Section A, Physical Sciences*, Vol. 27, No. 3, May, 1949, pp. 39–44, figs. 8 references.

Concerning an Instrument for Determining the Pressure and the Direction of Velocity in a Fluid. J. Kampe De Feriet, A. Martinot-Lagarde, and G. Rollin. (*L'Academie der Seances, Comptes Rendus des Seances, November 2, 1938.*) *U.S., David Taylor Model Basin, Translation No. 117*, January, 1943, 4 pp. 3 references. (Declassified.)

New Flow Element Produces Greater Differential with Practically No Pressure Loss. Henry W. Stoll. *Taylor Technology*, Vol. 2, No. 1, Summer, 1949, pp. 8–13, illus., diagrs., figs.

Design, installation, performance, and applications of the Taylor Pitot-Venturi flow element. Pressure differentials seven to ten times greater than those obtained with conventional Pitot tubes are produced with practically no pressure loss.

A Torsion Balance for Measuring Forces in Low Density Gas Flows. I. Estermann and E. D. Kane. *American Helicopter*, Vol. 20, No. 6, pp. 608–610, figs.

A torsion balance, designed to measure the force on a flat plate (or other simple geometry) in a low density gas flow, is described. The balance has been used with two interchangeable torsion member sizes, with diameters of 0.00064″ and 0.00090″, which measured forces up to a maximum of 0.6 mg. and 2.4 mg., respectively. Calibrations (obtained in still air using weights) were reproducible within 0.005 mg. and 0.04 mg. for the two sizes. Data obtained for a flat plate in a gas stream under large molecular mean free path conditions are presented.

The Use of Semi-Conducting Ceramic Glaze for the Measurement of Temperature. J. S. Forrest. *Journal of Scientific Instruments*, Vol. 26, No. 7, July, 1949, pp. 254, 255, fig. 4 references.

High Temperature Furnace for Electron Diffraction Studies of Thin Films. Eileen I. Alessandrini. *Journal of Applied Physics*, Vol. 20, No. 7, July, 1949, pp. 691–693, figs.

Measuring Air Velocity with a Thermopile. C. E. Hastings. *Electrical Engineering*, Vol. 68, No. 7, July, 1949, p. 582, diagr.

Some Basic Concepts of Thermoelectric Pyrometry; Peltier and Thomson Effects, Laws of Intermediate Temperatures and Metals. C. C. Roberts and C. A. Vogelsang. *Instrumentation*, Vol. 4, No. 1, Second Quarter, 1949, pp. 25–27, illus., diagrs.

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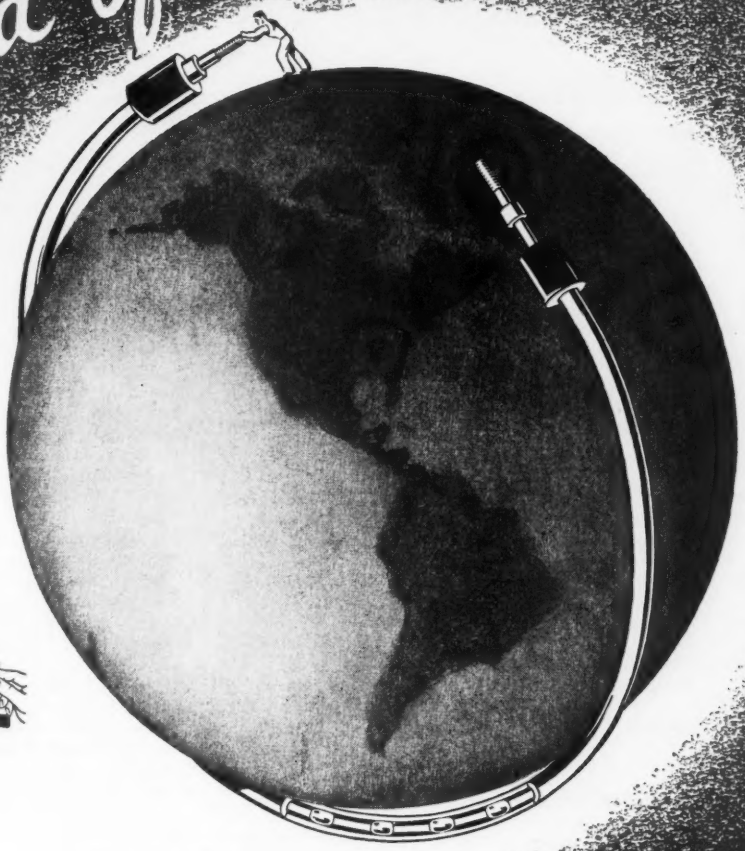

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The Prospects of Jet-Reaction Flight. II. Eugene Saenger. (*Interavia, Vol. 3, October, 1948, pp. 557–565*) *American Rocket Society, Journal*, No. 77, June, 1949, pp. 59–74, 94, diagrs. An extended discussion of rocket-engine combustion chambers which pertains to special problems involved in the design of flame nozzles and to the aerodynamics of reaction aircraft.

The Entropy Diagrams of Internal Combustion Engines Including Gas Turbines. P. Ostertag. (*Die Entropie-Diagramme der Verbrennungsmotoren Einschliesslich der Gasturbine. Second Edition. Julius Springer, Berlin, 1928.*) *U.S., Navy, The David Taylor Model Basin, Translation No. 94*, October, 1941, 73 pp., figs. (Declassified.)

Aircraft Flexible Pipe Assemblies. P. E. Charley. *The Aeroplane*, Vol. 77, No. 1989, July 22, 1949, pp. 110–112, illus.

Engines of the XVIIIe Salon de l'Aeronautique. *Aircraft Engineering*, Vol. 21, No. 245, July, 1949, pp. 204–208, illus., diagrs., figs.

JET & TURBINE (5)

Analysis of Performance of Jet Engine from Characteristics of Components. I—Aerodynamic and Matching Characteristics of Turbine Component Determined with Cold Air. Arthur W. Goldstein. *U.S., N.A.C.A., Report No. 878*, 1947. 18 pp., illus., diagrs., figs. 4 references. U.S. Govt. Printing Office, Washington. $0.15.

The performance of the turbine component of an N.A.C.A. research jet engine was investigated with cold air. The interaction and the matching of the turbine with the N.A.C.A. eight-stage compressor were computed with the combination considered as a jet engine. The overall performance of the engine was then determined. The internal aerodynamics were studied to the extent of investigating the performance of the first stator ring and its influence on the turbine performance. For this ring, the stream-filament method for computing velocity distribution permitted efficient sections to be designed, but the design condition of free-vortex flow with uniform axial velocities was not obtained. The actual air flow was 0.964 of the design value at design pressure ratio and speed was 0.98 at design speed and enthalpy drop. Rotative speed for optimum efficiency (0.875) was 180 r.p.s. as compared with the design speed of 134 r.p.s. (efficiency, 0.823).

General Algebraic Method Applied to Control Analysis of Complex Engine Types. Aaron S. Boksenbom and Richard Hood. *U.S., N.A.C.A., Technical Note No. 1908*, July, 1949, 42 pp., figs. 2 references.

A general algebraic approach to control problems of multivariable engines. This method leads to the conditions that must be imposed on the control characteristics to eliminate interaction between control variables and to an explicit solution for control characteristics that will yield any desired response action. The control characteristics for the engine, control system, and other units in the system were assumed to be linear and operational functions were used to express them. The system was generalized to allow for complex engine types having any degree of freedom, and algebraic methods were employed in setting up the characteristics of the engine, the control, the servo, and the measuring instruments. The algebraic methods were employed to combine the various separate units into a system that showed how various effects are transmitted throughout the entire system. A condensed matrix form illustrates the principal effects on controlled variables.

Description and Theoretical Discussion of a Special Type of Pressure Exchanger. Albrecht Hussmann. *U.S., Air Force, Technical Report No. F-TR-1189-ND (ATI No. 38398)*, April, 1949, 59 pp., diagrs., figs. 5 references.

The operation of a pressure exchanger as a second-stage compressor in a turbine power plant is such that the gases ordinarily required for operation of the second-stage compression turbine are available for useful work in an additional high-pressure turbine. The Comprex is a special type of exchanger wherein hot gases at high pressure, and small shock waves increase the pressure of cold intake air. The exchange takes place in horizontal helical cells on the surface of a rotor. Shock waves are introduced by timed rotation of the rotor and the sudden opening and closing of the inlet and outlet ports of the cells. Since the temperature of the cell walls is an average of that of the hot and cold gases the engine can work at higher combustion temperatures. The engine can also provide the first expansion in a normal cycle and increase the efficiency of the main turbine by allowing the gases to have a higher inlet temperature prior to the pre-expansion stage.

Design of Heat Exchangers for the Regenerative Cycle Aircraft Turboprop Engine. F. E. Romie, A. G. Guibert, and C. D. Coulbert. *American Society of Mechanical Engineers, Paper No. 49-SA-18*, June, 1949. 19 pp., figs. 1 reference. (Preprint.)

A comparison and tabulation of design characteristics of recuperative and regenerative heat exchangers for two hypothetical engines. The evaluation of an exchanger is based upon the comparative thermal efficiency of the engine with and without the exchanger. Thermal efficiency is a function of the specific work ratio, which varies with pressure losses up and downstream from the turbine. The regenerative type exchanger affords a decided saving in weight and volume of matrix for similar efficiencies obtainable with the recuperative type. Its relative advantages increase with increasing engine thermal efficiency.

Analysis of Jet-Propulsion-Engine Combustion-Chamber Pressure Losses. I. Irving Pinkel and Harold Shames. *U.S., N.A.C.A., Report No. 880*, 1947. 11 pp., diagrs., figs. 1 reference. U.S. Govt. Printing Office, Washington. $0.15.

The development and use of a combustion-chamber pressure-loss chart. Its use is restricted to combustion chambers having an unobstructed combustion zone. Pressure losses, due to fluid friction and to the addition of heat by combustion, are evaluated separately. Values of losses obtained with the chart are within 7 per cent of the values of losses obtained experimentally for cylindrical, annular, and ram-jet types of combustion chambers.

Fuel Spray Nozzles for Aircraft Gas Turbines. II. J. A. Bolt and M. F. Saxton. *Automotive Industries*, Vol. 100, No. 11, June 1, 1949, pp. 36–38, 56, illus., diagrs. 2 references.

Discussion of characteristics of constant-pressure variable-orifice and air atomizing nozzles, and of fuel dividers for equalizing fuel flow regardless of pressure-flow characteristics. Further development in the design of nozzle components requires analytical data on the definition and measurement of sprays and on the factors that influence combustion in a moving air stream.

Determination of Elastic Stresses in Gas-Turbine Disks. S. S. Manson. *U.S., N.A.C.A., Report No. 871*, 1947. 11 pp., figs. 3 references. U.S. Govt. Printing Office, Washington. $0.15.

A method for the calculation of elastic stresses in symmetrical discs, which is essentially a finite-difference solution of the equilibrium and compatibility equations for elastic stresses in a symmetrical disc. Account can be taken of point-to-point variations in disc thickness, in temperature, in elastic modulus, in coefficient of thermal expansion, in material density, and in Poisson's ratio. No numerical integration or trial-and-error procedures are involved, and the computations can be performed in rapid and routine fashion by nontechnical computers, with little engineering supervision. Checks on problems for which exact mathematical solutions are known indicate that the method yields results of high accuracy. Illustrations show the manner of treating solid discs, discs with central holes, and discs constructed either of a single material or of two or more welded materials. The effect of shrink fitting is taken into account by a very simple device.

New Aircraft and Engines. *The Aeroplane*, Vol. 77, No. 1989, July 22, 1949, pp. 92, 93, illus.

Design characteristics of the Bristol Proteus and the Rolls-Royce Clyde RC.3, and the differences between the de Havilland Goblin 4 and current types of engine.

Turbine-Engined Aircraft, Scope for Transport Operator; Viscount Designer's Paper in New York. George R. Edwards. *Modern Transport*, Vol. 61, No. 1576, June 11, 1949, p. 9, fig. (Extended summary of a paper.)

Turbine Engined Transport Aircraft. G. R. Edwards. *Flight*, Vol. 55, No. 2111, June 9, 1949, pp. 688 and 689, figs. (Extended summary of a paper.)

Turbine Transport Aircraft. George R. Edwards. *Airports &*

Air Transportation, Vol. 4, No. 73, July, 1949, pp. 139–141, figs. (Extended summary of a paper.)

The Propeller Gas Turbine in Service. F. M. Owner. *Flight*, Vol. 55, No. 2112, June 16, 1949, pp. 714–716, figs. (Summary of a paper.)

The Propeller Gas Turbine in Service. F. M. Owner. *The Aeroplane*, Vol. 76, No. 1983, June 10, 1949, pp. 660, 661, illus. (Extended summary of a paper.)

Automatic Control of Turbojet Engines. Clifford S. Cody. *Aero Digest*, Vol. 59, No. 1, July, 1949, pp. 46–48, 50, 52, 54, 106, illus., diagrs., figs.

Super-Sonic Thrust. V. Roger Tennant and Peter Kahn. *The Aeroplane*, Vol. 77, No. 1988, July 15, 1949, pp. 74–76, figs.

Engine Production in Australia; Organization for Production of Rolls-Royce Nenes, Testing and Research. *Aircraft Production*, Vol. 11, No. 130, August, 1949, p. 253, illus.

The Turbo-Jet. E. S. Thompson. *Antiaircraft Journal*, Vol. 92, No. 3, May-June, 1949, pp. 45–51, illus., diagrs.

Aero Engines in the Next Decade. F. R. Banks. *The Aeroplane*, Vol. 76, No. 1981, May, 1949, pp. 602, 603, 604, illus.

Avro Chinook. *Shell Aviation News*, No. 132, June, 1949, p. 24, illus.

Tudor Double-Nene Layout. *The Aeroplane*, Vol. 77, No. 1987, July 8, 1949, p. 42, illus.

Insulation Blankets for Aircraft. Leon Parker and Donald A. Floto. *Aero Digest*, Vol. 59, No. 1, July, 1949, pp. 62, 63, illus. Refrasil, a fibrous silica developed by the H. I. Thompson Company, is a material with low-weight bulk, and a low-heat transfer coefficient suitable for insulating the tail cones and tail pipes of jet-aircraft engines.

Ducted Fan Engine Under Study; Unit Combines Best Turbojet and Turboprop Features to Close Great Performance Gap Between the Two. Robert McLarren. *Aviation Week*, Vol. 51, No. 2, July 11, 1949, pp. 23–25, 27, diagr., figs. 6 references.

280 Subcontractors Feed GE Plant; Suppliers Throughout Country Furnish Components for Final Assembly into J-47 Jet Engines at Lockland. *Aviation Week*, Vol. 50, No. 26, June 27, 1949, pp. 29, 30, illus.

Partial Admission Aids Efficiency; Blocking of Nozzle Annulus Offers Method to Slow Jet Engine Speed Without Taking Fuel Consumption Penalty. Robert McLarren. *Aviation Week*, Vol. 50, No. 23, June, 1949, pp. 27, 28, diagrs. 3 references.

Nene Production at CAC; The Rolls-Royce Nene 11 Turbojet Program at the Commonwealth Aircraft Corporation's Factory. *Aircraft*, Vol. 27, No. 7, April, 1949, pp. 20–23, 46, illus.

RECIPROCATING (6)

High-Altitude Flight Cooling Investigation of a Radial Air-Cooled Engine. Eugene J. Manganiello, Michael F. Valerino, and E. Barton Bell. *U.S., N.A.C.A., Report No. 873*, 1947. 17 pp., illus., diagrs., figs. 8 references.

Correction of engine-cooling data for various high altitudes to provide a basis for predicting high-altitude cooling performance from sea-level or low-altitude experimental results. The usual N.A.C.A. cooling-correction method is modified to account for cooling-air compressibility effects. A theoretical analysis checked the validity of the use of cooling-air exit density in the correlation equation for approximating the compressibility effects. Cooling predictions are accurate to an altitude of 20,000 ft.

Rheological Criteria for Two-Stroke Cycle Scavenge Systems. E. Niedermayer. (*Maschinenbau und Wärmewirtschaft, Vol. 4, No. 1, 2, January-February, 1949; pp. 1–7, 18–24, illus.*) *The Engineers' Digest*, Vol. 10, No. 5, 6, May, June, 1949, pp. 152–156, 193–197, figs., diagrs. 3 references.

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Multiple-Port Fuel Injection Beneficial but Costly. A. J. Volz, S. M. Smith, and M. R. Balis. *SAE Journal*, Vol. 57, No. 7, July, 1949, pp. 54, 55, diagrs. (Extended summary of a paper: Fuel Systems and Carburetors for Personal Aircraft.)

Engine Overhaul Life. R. C. Morgan. *The Aeroplane*, Vol. 76, No. 1982, June 3, 1949, pp. 643, 644, figs.

ROCKET (4)

Investigation of Some Parameters Affecting Over-All Rocket Performance. C. H. Harry. *American Rocket Society, Journal*, No. 77, June, 1949, pp. 51–58, diagrs. Simplified method of integrating the trajectory equations, and a study of the effects of mass ratio, of the thrust-to-gross weight ratio, and of the rate of fuel consumption on performance.

The Design of Rocket Motors. J. Humphries. *British Interplanetary Society, Journal*, Vol. 8, No. 3, May, 1949, pp. 93–114, diagrs., figs. 38 references. An extensive survey of design requirements including specific recommendations for the selection of propellants, combustion-chamber design, and rocket testing.

The 109-718 Auxiliary Rocket Power Unit. Heinz Gartmann. *Interavia*, Vol. 4, No. 7, July, 1949, pp. 413–415, illus., diagrs. General description of components, propellants, operation, and history of a rocket booster for attachment to jet engines.

Design and Experimentation on a Basic Rocket Engine. A. Bernstein, F. D. Linzer, N. Y. Rothmayer, and A. Sherman. *American Rocket Society, Journal*, No. 77, June, 1949, pp. 79–89, diagrs.

A Charging Value for Compressed-Air Rocket Models. Pierce G. Couperus. *American Rocket Society, Journal*, No. 77, June, 1949, pp. 90–93, illus., diagrs.

Nose Drive or Tail Drive? *British Interplanetary Society, Journal*, Vol. 8, No. 3, May, 1949, pp. 120–123, figs. The inherent stability of the nose and of the tail drive is the same but the nose drive permits the design of more effective aerodynamic control surfaces.

The Rocket and Associated Handling Problems. A. R. Frithsen. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 14, July 15, 1949, pp. 18–21, fig.

The Atomic Rocket Motor. II. Melvin G. Whybra. *Rocketscience*, Vol. 3, No. 2, June, 1949, pp. 48–54, diagrs.

Production (36)

Making Ends Meet. Boyd K. Bucey. *Boeing Magazine*, Vol. 19, No. 7, July, 1949, pp. 10, 11, illus.

Brief description of the use of all-dural jigs for positive control of dimensional changes. The part under construction has the same expansion-contraction characteristics in length and width as the entire jig in which it is contained.

Some Developments in Aircraft Production. *Aeronautics*, Vol. 21, No. 2, July, 1949, pp. 65, 66, 68, 71, 72, diagrs. (Extended summary of a paper.)

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Production—The Designer's Contribution. I—Principles of Efficient Production; Special Problems of Manufacture; Joining Processes. Frank Radcliffe. *Aircraft Production*, Vol. 11, No. 129, July, 1949, pp. 241–245, illus., diagr. 12 references.

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Hermes IV and Hastings. IV—Mainplane Construction and Assembly: Manufacture of Tail Surfaces. S. C. Poulsen. *Aircraft Production*, Vol. 11, No. 128, June, 1949, pp. 186–195, illus., diagrs.

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Percival Prince. I—Basic Production Equipment; Stretch Forming; Soft-Metal Blanking-Tools; Fuselage Construction. S. C. Poulsen. *Aircraft Production*, Vol. 11, No. 129, July, 1949, pp. 218–223, illus., diagrs.

Percival Prince. II—Pre-Assembled Skin-Panels Fuselage Fixtures and Assembly Wing Structure and Assembly Wooden Fixtures. S. C. Poulsen. *Aircraft Production*, Vol. 11, No. 130, August, 1949, pp. 254–261, illus.

"Without my Sperry Gyrosyn I couldn't have won!"

James Stewart and Mrs. Stewart congratulate the winner. Stewart owns the plane.

Navigating solely by dead-reckoning with the Gyrosyn* Compass, Joe De Bona at the controls of his F-51-C "Thunderbird" set a new race record of 470.136 miles an hour in the 1949 Bendix race.

"I was able to 'steer to a degree' with the Sperry Gyrosyn," De Bona said. "After setting the Gyrosyn at take-off in California to insure the best 'take-off heading,' I climbed to 27,000 feet and navigated a great circle course entirely by this instrument. To confirm my 'on course' accuracy, I used visual checks along the way.

"For example, I dead-reckoned about 850 miles to Colorado Springs, and computed a course 10 miles south of the city. It looked like about 6 to 7 miles south when I passed over. Later, my course called for a heading which cut between Goshen and Ft. Wayne, Indiana. When I got there, I split the two towns accurately as planned."

This transcontinental speed dash tests the skill of the pilot, and the flying ability and stamina of his plane. In winning the 2100-mile race in 4 hours and 16 minutes, Joe De Bona proved that he had both. And in flying at a speed where a minute means about 8 miles, he was able to prove once again, the importance of pin-point navigation and the Gyrosyn Compass.

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Structure-Stiffness Tests on the Bristol Brabazon; Hydraulic Loading and Multiple Measurement Stations. *Aircraft Production*, Vol. 11, No. 128, June, 1949, pp. 209–211, diagrs.

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Development of Welding Techniques on Combustion Type Aircraft Heaters. *Aircraft Heating Digest*, Vol. 1, No. 2, June, 1949, p. 2, illus.

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Radiant Heating of Factories; A Review of Basic Principles and Systems. Leo Walter. *Aircraft Production*, Vol. 11, No. 130, August, 1949, pp. 274–277, figs.

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Centreless Grinding of Headed Pieces; Monotonous Operation Eliminated and Production Increased by an Automatic Machine: (Scrivener Magnetic Loading Device). *Aircraft Engineering*, Vol. 21, No. 244, June, 1949, p. 201, illus., diagrs.

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Portrait of a Pioneer. *Flight*, Vol. 55, No. 2112, June, 16, 1949, p. 713, illus.

Rotating-Wing Aircraft (34)

Rotating-Wing Problems. J. W. Mazur. *Flight and Aircraft Engineering*, Vol. 55, No. 2109, May, 1949, pp. 626–629, illus., diagrs. (Extended summary of a paper: Flight Testing of Helicopters by the U.S. Navy).

An Analysis of the Transition of a Helicopter from Hovering to Steady Autorotative Vertical Descent. A. A. Nikolsky and Edward Seckel. *U.S., N.A.C.A., Technical Note No. 1907*, June, 1949, 29 pp., figs. 1 reference.

An analytical method for assessing the influence of design variables upon the transient motion of a helicopter following power failure while hovering. Based upon a numerical integration of the equations of motion, its results indicate that the effect of hinging the blade in establishing steady autorotation is negligible. To avoid excessive blade stalling and the consequent possibility of rotor stoppage, which is the only case for which this analysis is valid, the blade pitch should be reduced rapidly following power failure and the blade moment of inertia made large. The average transition time for cases investigated was about 6 sec., and the corresponding average altitude loss was about 120 ft. The sample calculations and graphs of computed transitions are for a typical helicopter.

A Strange Phemonenon—Blade Position Instability. Henrich Focke. *American Helicopter*, Vol. 15, No. 8, July, 1949, pp. 6–10, 21, figs.

Analysis of the dynamical consequence of the increased angle of incidence of a cardan-joint-hinged blade, when flapping and lagging angles increase together. Lift- and drag-moments about the hinge are increased, the increase being greater than the corresponding increase of the restoring moments of the centrifugal force. The blade goes either upward or rearward, or both, until it reaches a mechanical stop. For a given rotor, with a given cinematic arrangement of hinging its blades of a given weight, there is a certain limit of moment and therefore a certain limit of power which cannot be increased without producing this blade position instability.

Two-Dimensional Investigation of Five Related NACA Airfoil Sections Designed for Rotating-Wing Aircraft. Raymond F. Schaefer, Laurence K. Loftin, Jr., and Elmer A. Horton. *U.S., N.A.C.A., Technical Note No. 1922*, July, 1949, 41 pp., figs. 8 references.

Five NACA airfoil sections intended for use in rotor blades have been designed and tested in the Langley two-dimensional low-turbulence tunnel. The airfoils have thicknesses that vary from 9 per cent to 15 per cent of the chord and theoretical design lift coefficients that vary from 0.3 to 0.7. Theoretical-pressure-distribution data and the measured two-dimensional aerodynamic characteristics have been determined at Reynolds Numbers from 0.9×10^6 to 2.6×10^6. Theoretical calculations for different flight conditions are also included to indicate the relative performance of sample rotors employing the different airfoils.

Design for a Rotor Driven by Impressed Flapping and Feathering. Paul Baumgardtl. *American Helicopter*, Vol. 15, No. 7, June, 1949, pp. 11, 21, diagr.

Automatic Stabilization of Helicopters. G. J. Sissingh. *American Helicopter*, Vol. 15, No. 7, June, 1949, pp. 6–10, 20, 21, figs. 3 references. (Extended summary of a paper.)

Helicopter Power Plant; Alvis Leonides. *Shell Aviation News*, No. 132, June, 1949, pp. 22, 23, illus.

Some Points About the Helicopter. A. McClements. *The Technical Instructor*, Vol. 4, No. 5, May, 1949, pp. 3–9, illus., diagrs. 1 reference.

The 18th Paris Aeronautical Exhibition. G. Colin Cooper. *American Helicopter*, Vol. 15, No. 7, June, 1949, pp. 16, 17, 24, illus.

A Simplified Rotor Control System. Paul Baumgardtl. *American Helicopter*, Vol. 15, No. 8, July, 1949, pp. 11, 20, 21, figs.

General description of a type of control which requires only one swashplate between the two rotors of a coaxial helicopter.

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Seibel 'Copter (S-4) Flying CAA Tests. *Aviation Week*, Vol. 50, No. 25, June 20, 1949, p. 42, illus.

The Pressure-Jet Helicopter; An Analysis of the Design Factors for Optimum Performance. *Flight*, Vol. 55, No. 2111, June 9, 1949, pp. 672–674, figs. (Extended summary of a paper.)

The Bristol 171 Helicopter. Raoul Hafner. *Helicopter Association of Great Britain, Journal*, Vol. 2, No. 4, January-February-March, 1949, pp. 31–42, illus., diagrs. 2 references.

The Cierva "Air Horse." J. S. Shapiro. *Helicopter Association of Great Britain, Journal*, Vol. 2, No. 4, January-February-March, 1949, pp. 43–58, diagrs.

Piasecki's Helicopters. Alexander Klemin. *Aero Digest*, Vol. 59, No. 1, July, 1949, pp. 58, 59, 84, 85, 87, 88, illus.

The Kellett XH-10 Heavy-Weight Helicopter. *Interavia*, Vol. 4, No. 7, July, 1949, pp. 425–427, illus., diagrs.

Glow Tubes for Copter Tip Lights. *Aviation Week*, Vol. 50, No. 25, June 20, 1949, p. 33, figs.

A Helicopter Rotor Testing Tower. *The Engineer*, Vol. 187, No. 4874, June 24, 1949, pp. 685–688, illus., diagrs.

Research on Helicopters at the R.A.E. with Special Reference to the Stability of Multi-Rotor Helicopters. H. B. Squire. *The Aeroplane*, Vol. 76, No. 1984, June 17, 1949, pp. 693, 694, figs. (Extended summary of a paper.)

Rotor Testing; Design and Development of the Bristol Tower. *Flight*, Vol. 55, No. 2114, June 30, 1949, p. 771, illus. (Summary of a paper.)

U. S. Marine Corps' Assault Copters. Frank Coleman. *American Helicopter*, Vol. 15, No. 7, June, 1949, pp. 15, 23, illus.

General Problems of the Helicopter for Civil Use. H. Roxbee-Cox. *Helicopter Association of Great Britain, Journal*, Vol. 2, No. 4, January-February-March, 1949, pp. 2, 3.

The Operational Point of View. R.A.C. Brie. *Helicopter Association of Great Britain, Journal*, Vol. 2, No. 4, January-February-March, 1949, pp. 3–9, diagrs.

Helicopters Increasingly Important in Naval Operations. John L. Vandegrift, Jr. *U.S. Air Services*, Vol. 34, No. 6, June, 1949, pp. 14–16, 18, illus.

The Flying Bananas and How They Grew; Piasecki Helicopter Corporation Developed from an Engineers' Bull Session. Edgar Deigan. *Flying*, Vol. 45, No. 1, July, 1949, pp. 24, 25, 67, illus.

Archaeology by 'Copter. Neil Gahagan. *The Bee-Hive*, Vol. 24, No. 23, Summer, 1949, pp. 22, 23, illus.

Sciences, General (33)

CHEMISTRY

Ob Obshchem Vide Uravnenii Kinetiki Khimicheskikh Reaktsii v Gazakh (On the General Aspect of the Equations of the Kinetics of Chemical Reactions in Gases). L. I. Sedov. *U.S.S.R., Akademiia Nauk, Doklady, New Series*, Vol. 60, No. 1, 1948, pp. 73–76. 1 reference.

MATHEMATICS

The Synthesis of Electric Networks According to Prescribed Transient Conditions. Morton Nadler. *Institute of Radio Engineers, Proceedings*, Vol. 37, No. 6, June, 1949, pp. 627–630, figs. 11 references.

By use of the Laplace transform, a network function may be obtained yielding a prescribed transient response. The procedure is based directly on the prescribed function of time, without consideration of amplitude or delay as a function of frequency. An example is given in which the Poisson-Stieltjes integral is employed for the physical realization of a network function which involves a transcendental term.

Symbolic Nomenclature for Sinusoids. W. R. LePage. *Electrical Engineering*, Vol. 68, No. 7, July, 1949, pp. 561–565, figs. 11 references.

MECHANICS—VIBRATION

Free Periodic Motions of an Undamped Two-Degree-of-Freedom Oscillatory System with Nonlinear Unsymmetrical Elasticity. Walter W. Soroka. *Journal of Applied Mechanics, Paper No. 49-SA-6*, June 27, 1949, 6 pp., figs. 4 references. (Preprint.)

Precise solutions for a two-degree-of-freedom oscillatory system that is characteristic of an aircraft propeller-engine-supercharger installation containing a soft preset spring. The periodic free motions of a system in which one spring is nonlinear, indicate the possibility of highly unconventional motions when the nonlinearity is pronounced, which may be overlooked in the usual approximate treatment of nonlinear systems. By solving the differential equations of motion for each linear piece of the deflection curve and inserting into these general solutions the conditions of continuity of displacement, velocity, and acceleration through each break in the deflection curve, the phase angles and amplitudes of the sets of modes representing the oscillation in its different stages, can be determined. The results presented show that one mass may oscillate several times while the other mass is going through one oscillation, and that the ratio of oscillations of one mass with respect to the other changes with amplitude.

A Method of Equivalent Linearization for Non-Linear Oscillatory Systems with Large Non-Linearity. Carl A. Ludeke. *Journal of Applied Physics*, Vol. 20, No. 7, July, 1949, pp. 694–699, figs.

Resonance Amplifies Forces in Vibration Machines. J. Paul Walsh. *Machine Design*, Vol. 21, No. 7, July, 1949, pp. 113–115, diagrs., figs.

Structures (7)

A Reconsideration of Deformation Theories of Plasticity. D. C. Drucker. *American Society of Mechanical Engineers, Transactions*, Vol. 71, No. 5, July, 1949, pp. 587–592, figs.

Deformation theories of plasticity for strain-hardening materials are defined as those that postulate that the components of elastic and permanent strain are completely determined by the existing components of stress. The assumption is made that there is some criterion, in terms of stress, for loading or increase in plastic deformation. A common supposition of this nature is that the permanent strain will increase when the octahedral shearing stress increases. It is shown that, no matter what the loading criterion, these deformation theories of plasticity lead to the unacceptable conclusion that large (finite) changes in the components of permanent strain may accompany infinitesimal increases in loading despite strain hardening. Simple illustrations are given and it is demonstrated that an incremental, or so-called flow theory eliminates this undesirable feature.

O Raspredelenii Deformatsii po Dline Obraztsa pri Kruchenii (On the Distribution of Deformation Along the Length of a Specimen Under Torsion). M. V. Iakutovich and F. P. Rybalko. *U.S.S.R., Akademiia Nauk, Doklady, New Series*, Vol. 60, No. 2, 1948, pp. 227–229, figs. 3 references.

The Stress Analysis of Simplified Structures. G. E. H. Rice. *Aircraft Engineering*, Vol. 21, No. 245, July, 1949, pp. 209–213, figs.

The Elementary Theory of Stressed Skin Construction. II. W. S. Hemp. *Aircraft Engineering*, Vol. 21, No. 244, June, 1949, pp. 191, 192.

Fundamental assumptions that govern the analysis of stressed skin construction. The longitudinal reinforcing members, augmented with suitable contributions from the skin, carry primarily only direct loads along their length. The skin covering carries primarily only shear stresses in its own surface in axes determined by the directions of the longitudinal and transverse reinforcing members. The transverse reinforcing members primarily carry loads in their own planes. The principal external forces may be assumed applied to the transverse reinforcing members in the planes of these members.

On the Natural Frequencies of a Reinforced Circular Cylinder. W. S. Hemp. *College of Aeronautics, Cranfield, England, Report No. 26*, March, 1949, 8 pp., figs.

Calculation of the natural frequencies of flexural vibration parallel to a diametral plane in an ideal structure representative of an aircraft fuselage for comparison with the usual calculation that neglects the shear flexibility. A simplified "shell" theory permits proper allowance to be made for the shear stresses and the corresponding displacements. Although the usual theory gives fair approximation of the fundamental frequency, it is already seriously in error in estimating the first overtone. Frequencies calculated on the assumption that flexibility is of primary importance are fair approximations at the third overtone. A method of calculation that is more accurate than the usual theory of beam vibration is required for anything more than a rough estimation of fuselage frequencies.

Computation of Thin-Walled Prismatic Shells. V. Z. Vlasov. (*Prikladnaia Matamatika i Mekhanika, Vol. 8, No. 5, 1944.*)

U.S., N.A.C.A., Technical Memorandum No. 1234, June, 1949, 51 pp., figs. 5 references.

A method for solving the plane problem of the theory of elasticity for a rectangular region which can be applied to prismatic shells by assuming a finite number of rectangular plates to comprise their surface. The plates are rigidly joined at their edges and follow the linear law of stress distribution when bending in their own planes. Resistance of the cross section to distortion is assumed to arise from the section acting as a bend.

Strength and Failure Characteristics of Metal Membranes in Circular Bulging. W. F. Brown, Jr., and F. C. Thompson. *American Society of Mechanical Engineers, Transactions*, Vol. 71, No. 5, July, 1949, pp. 575–585, figs. 16 references.

Deflection of Beams by the Operational Method. William T. Thomson. *Franklin Institute, Journal*, Vol. 247, No. 6, June, 1949, pp. 557–568, figs. 6 references.

The operational method of Laplace transformation offers the simplest approach to the beam problem. Instead of writing equations for each interval between concentrated loads, the operational method accounts for any loading by a single equation in terms of boundary values at the origin. Even beams with abrupt changes in cross section are not difficult to plot, and the method can be used for continuous beams.

Theory and Tests on the Plastic Stability of Plates and Shells. P. P. Bijlaard. *Journal of the Aeronautical Sciences*, Vol. 16, No. 9, September, 1949, pp. 529–541, figs. 46 references.

Buckling of plates and shells superimposes an additional state of stress on the original one. The assumption of plastic deformation, which is governed only by the amount of elastic shearing energy at the point in question, leads to smaller buckling stresses than that of "plastic flow." Under this assumption, the theory is in good agreement with tests by Kollbrunner and by the N.A.C.A. The ratio between plastic and elastic buckling stress is highest when the proportions of the deviator components, as superimposed by buckling, differ most from the proportions of the original deviator components. The stress-strain relations are derived by writing the infinitely small excess strains as total differentials, and computing the partial derivatives of the strains with respect to the stresses. The differential equation for plate buckling is derived, and results of its application to several kinds of loading and boundary conditions are tabulated. This theory for the buckling of shells is compared with those of Ilyushin, Stowell, Handelman, and Prager.

Shear Buckling of Infinitely Long Simply Supported Metalite Type Sandwich Plates. Paul Seide. *U.S., N.A.C.A., Technical Note No. 1910*, July, 1949, 20 pp., figs. 11 references.

A theoretical solution is obtained for the problem of the shear buckling of infinitely long simply supported elastic Metalite type sandwich plates. An approximate correction is suggested for the determination of the critical shear stresses of plates that buckle in the plastic range.

Ob Uprugo-Plasticheskom Sostoianii Plastinki (On the Elasto-Plastic Condition of a Plate). A. P. Sokolov. *U.S.S.R., Akademiia Nauk, Doklady, New Series*, Vol. 60, No. 1, 1948, pp. 33–36, fig. 1 reference.

Skin-Panel Integral Construction; Some American Experimental Designs. *Aircraft Production*, Vol. 11, No. 130, August, 1949, p. 263, figs.

Notes on Sandwich Construction. J. Lockwood Taylor. *Aircraft Engineering*, Vol. 21, No. 244, June, 1949, p. 196. (Extended summary of a paper.)

Readers' Forum: On the Unsteady Motion of Delta Wings. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 16, No. 9, September, 1949, pp. 568, 569. 2 references.

A Formulation of the Aeroelastic Problem for a Swept Wing. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 16, No. 8, August, 1949, pp. 477–490, fig. 15 references.

Differential equations for the equilibrium of a swept elastic wing under aerodynamic and inertial loads are developed according to the strip theory under the assumption that wing bending and torsion occur along a straight line. The integral forms of these equations are obtained as the energy balances. The lift and moment coefficients are expressed in terms of the initial configuration and elastic deflections. In addition to a discussion of several methods of solution of the differential and integral aeroelastic equations, an approximate solution is given for the energy equations. A numerical example illustrates the seriousness of the aeroelastic problems that are introduced by sweepback. These are the loss of static stability and trim effectiveness and the modification of the dynamic stability derivatives. An appendix contains a solution for lift distributions on a rigid swept wing.

Significant Stress and Failure in Static and Fatigue Loading. Charles Lipson, G. C. Noll, and L. S. Clock. *Product Engineering*, Vol. 20, No. 7, July, 1949, pp. 130–135, figs.

Effects of type and mode of loading on the significant stress as related to failure of machine parts, and the effect of abrupt changes in shape on stress distribution. Factors for geometric stress concentration, fatigue stress concentration, and notch sensitivity are evaluated in terms applicable to the determination of design stresses for finite and infinite life.

Application of Electrical Resistance Strain Gauges. A. L. Tannahill. *The Engineer*, Vol. 187, No. 4872, June 10, 1949, pp. 630–633, diagrs. 8 references.

Standardized techniques for affixing electrical resistance strain gages and temperature compensators to the interior and exterior of pressure vessels. Proper application of the elements and protection against droughts, humidity, or liquids ensure consistent accuracy of initial readings.

Aircraft Materials from the Designer's Point of View. A. E. Russell. *The Aeroplane*, Vol. 76, No. 1983, June 10, 1949, pp. 680, 681, figs. (Extended summary of a paper.)

The Life of Aircraft Structures. H. A. Wills. *The Aeroplane*, Vol. 76, No. 1984, June 17, 1949, pp. 695, 696. (Extended summary of a paper.)

Readers' Forum: Note on Life Expectancy Analysis of Structures. George Gerard. *Journal of the Aeronautical Sciences*, Vol. 16, No. 9, September, 1949, pp. 572, 573, figs. 2 references

Some Related Oscillation Problems. W. J. Duncal. *College of Aeronautics, Cranfield, England, Report No. 27*, April, 1949, 17 pp., diagrs. 3 references.

Two means of establishing a relation between a pair of oscillation problems. In the first method, the displacements of the two problems are connected by a linear differential operator. The set of natural frequencies is identical for both. The transformed boundary condition is interpreted physically. A flywheel on a uniform shaft can be transformed by this method into a flexible coupling and a mass carried on a uniform beam into a flexible hinge. In the second method, the connection between the problems is established by use of the concept of mechanical admittance where the frequency equations are simply related but the frequencies are not.

Form of Notch in Impact Testing. J. Pomey, A. Cadihac, and R. Coudray. (*Revue de Métallurgie, Vol. 45, November, December, 1948, pp. 455, 525.*) *The Engineer*, Vol. 187, No. 4874, June 24, 1949, pp. 690–693, figs. (Extended summary of a paper.)

The General Theory of Cylindrical and Conical Tubes Under Torsion and Bending Loads. VI. J. Hadji-Argyris and P. C. Dunne. *Royal Aeronautical Society, Journal*, Vol. 53, No. 462, June, 1949, pp. 558–620, figs., tables. Single- and many-cell tubes of arbitrary cross section with rigid diaphragms.

Flutter and Stability. W. J. Duncan. *Royal Aeronautical Society, Journal*, Vol. 53, No. 462, June, 1949, pp. 529–549, Discussion, pp. 550–557, figs. 72 references.

A discussion of the nature of flutter, its physical causation, the main aspects of a workable theory for its analysis, prediction, and prevention, and some aspects of general aircraft stability and control. The presentation is nonmathematical.

Thermodynamics (18)

Studies on Heat Transfer in Laminar Free Convection with the Zehnder-Mach Interferometer. E. R. G. Eckert and E. E. Soehngen. *U.S., Air Force, Technical Report No. 5747* (*ATI No. 44580*), December 27, 1948, 21 pp., illus., figs. 15 references.

Zehnder-Mach interferometric investigation of heat transfer in thermal free two-dimensional convection air flow on bodies of different shape. Information obtained is applicable to cooling and insulating problems connected with handling special fuels, and to the study of cooling problems in gas turbines and to radial flow phenomena in turbo machinery.

Thermodynamic Charts for Internal-Combustion-Engine Fluids. W. J. McCann (Revised by L. R. Turner and Emory A. Bauer). *U.S., N.A.C.A., Technical Note No. 1883*, July, 1949, 18 pp., figs. 4 references.

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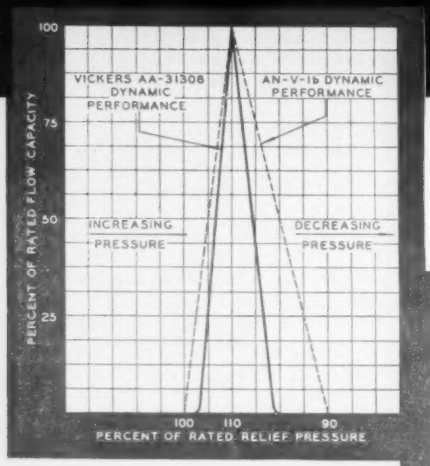

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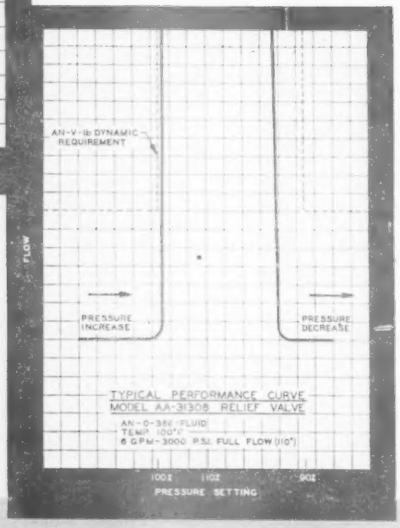

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Water-Borne Aircraft (21)

The Relative Efficiencies of Large Landplanes and Flying Boats. D. Keith-Lucas. *Flight*, Vol. 55, No. 2112, June 16, 1949, pp. 716 and 717. (Summary of a paper.)

The Relative Efficiencies of Large Landplanes and Flying Boats. D. Keith-Lucas. *The Aeroplane*, Vol. 76, No. 1983, June 10, 1949, pp. 664, 679. (Extended summary of a paper.)

Model Statistics as Compiled by the Hamburg Model Basin. Werner Hinterthan. *U.S., Navy, The David Taylor Model Basin, Report No. 674*, December, 1948, 7 pp., figs.

Wind Tunnels (17)

A Simple Approach to Wind Tunnel Constriction Effect. W. J. Duncan. *Aircraft Engineering*, Vol. 21, No. 244, June, 1949, pp. 180–183, diagrs.

A review of the problem of the influence of the walls on the increase of the velocity in the neighborhood of a model under test. For a perfect fluid, considerations of continuity suffice to establish an exact value of the mean interference for any cross section of the tunnel in terms of the perturbation velocity that would be caused by the same model in the absence of the wall. Assuming an incompressible flow and a body that is small in relation to the tunnel width, the interference velocity at the axis is 0.822 times the mean interference velocity. The interference velocity near the walls is therefore somewhat greater than along the axis of the tunnel. When the fluid is compressible and the linearized subsonic theory is applied, it is seen that the influence of compressibility applies to the interference at all parts of the channel and therefore to the mean interference velocity. It is shown that the interference velocity for a small model is increased in proportion to $1/\beta^3$, where $\beta = \sqrt{(1 - M^2)}$, and M is the Mach Number.

Study of the Condensation of the Components of Air in Supersonic Wind Tunnels. I—Absence of Condensation and Tentative Explanation. Seymour M. Bogdonoff and Lester Lees. *Princeton University, Aeronautical Engineering Laboratory, Report No. 146*, May 25, 1949, 40 pp., illus., figs. 13 references.

Experimental study for the condensation of air components predicted by the Volmer theory of nucleation. At Mach Number 4.6, with stagnation pressures to 860 lbs. per sq.in. at atmosphere and stagnation temperatures as low as 238°K., there is no evidence of condensation either from schlieren observations or pressure distribution measurements. The Volmer theory fails when the condensation nuclei become so small that a "droplet," consisting of 35–40 molecules or less, can no longer be considered as a continuous liquid phase. It is concluded that preheating of the air to avoid condensation is not required, regardless of the Mach Number, for the ranges of stagnation pressures and temperatures tested.

Preliminary Investigation of the Use of Afterglow for Visualizing Low-Density Compressible Flows. Thomas W. Williams and James M. Benson. *U.S., N.A.C.A., Technical Note No. 1900*, June, 1949, 23 pp., illus., diagr. 9 references.

Comparison of afterglow photographs with Schlieren photographs of densities corresponding to static pressures of 3 to 8 mm. of mercury in the supersonic flow about wedges. Afterglow was more effective when applied to low densities, and may be more effective for considerably lower densities. Commercial nitrogen produced the brightest photographable afterglow. This method of visualization is recommended when the general features of the flow, rather than accurate details, are desired.

Manufacture of Zehnder-Mach Interferometer. Ernst R. G. Eckert, R. M. Drake, Jr., and Eric Soehngen. *U.S., Air Force, Technical Report No. 5721 (ATI No. 34235)*, August 31, 1948, 24 pp., illus., figs. 20 references.

Description of the apparatus, its adjustments, and optical system. A schlieren picture on the viewing screen, in juxtaposition to the interference picture, provides a means of obtaining a preliminary qualitative interpretation of the interference picture. The instrument has been tested for ease and stability of adjustment, illumination, and resolving power for the interference lines and their straightness, and found satisfactory for the investigation of heat transfer and temperature fields in the flow in combustion chambers and nozzles.

French Practical Aerodynamic Methods. Jean Brocard and Francois Hussenot. *Royal Aeronautical Society, Journal*, Vol. 53, No. 462, June, 1949, pp. 487–528, illus., diagrs., figs.

A discussion of French methods for the conversion of low-speed wind-tunnel data on longitudinal stability, deflection and forces on the control surfaces, effect of thrust and slipstream on the trim of the aircraft, and performance. Powered models are used for the wind-tunnel tests. A new technique of flight testing, wherein the polar curve is derived from measurement from flight with feathered propellers, supplies terms for direct comparison with the models.

New Tunnel Throat Aids Transonic Study; NACA Develops Large Test Section to Remove Research Blind Spot. Robert Hotz. *Aviation Week*, Vol. 50, No. 25, June 20, 1949, pp. 12, 13, illus.

Solving a Wind Tunnel Problem; In the Study of Superaerodynamics, Low Density Flow Visualization, NACA Uses Nitrogen Afterglow. Robert McLarren. *Aviation Week*, Vol. 50, No. 25, June 20, 1949, pp. 19, 20, 22, 24, diagrs. 6 references.

North-American Supersonics; Vacuum-Type Tunnel Designed to Give Velocity of Mach 5.25. *Flight and Aircraft Engineering*, Vol. 55, No. 2109, May, 1949, p. 618, illus., diagrs.

New (NACA) Research Methods Revealed. *Aviation Week*, Vol. 50, No. 23, June, 1949, pp. 21, 22, illus.

I.A.S. National Meeting Schedule

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Aeronautical Reviews

Books

Analytical Mechanics of Gears

By Earle Buckingham. New York, McGraw-Hill Book Company, 1949. 546 pp., diagrs. $10.

We accept gears and gearings as instinctively, almost, as the wheel or the lever. Gears have always been there to serve us. In aviation, gearing must absorb great power in little space, give an efficiency of close to 97 or 98 per cent, be almost noiseless, never show signs of wear, never fail, and require little maintenance or care in lubrication. We take it for granted that the gearings requirements of a turboprop power plant can be met as readily as those of a helicopter transmission. There are tables and manuals from which to select them, or, failing this, a specialist will always solve our problems. Their theory is something short and elementary that we read in a book on kinematics in sophomore or junior year and have never bothered with since.

Then how can it be possible that Professor Buckingham should write a large profound mathematical treatise solely devoted to the analytical mechanics of gears, without attempting even to write a manual of gear design?

The answer is that the invention of gear teeth represents an evolution over centuries, perhaps over thousands of years, and that the problem of *uniform motion* between two geared wheels is one of subtlety and complexity. In the seventeenth century, such celebrated astronomers as Olaf Roemer, and such distinguished mathematicians as Robert Willis and Philiffe de Lapire were thrilled and proud to discuss this problem of uniform motion, to study and apply epicycloidal and involute forms, and to use the resources of analytical geometry, at that time a newly invented branch of mathematics. Since those early days this branch of applied science has never ceased to grow.

Perhaps it is not so remarkable, therefore, that Earle Buckingham, author of the widely known *Manual of Gear Design*, with a whole career of research to his credit, should have undertaken to write this certainly unique and possibly definitive book. There is no better way of defining its purpose and scope than to quote some sentences from the Preface:

"This text is the gratification, to some degree, at least, of a suppressed desire of some twenty-five years standing: this has been the development of a reasonably complete mathematical analysis of the mechanics of gearing.

"This is not a text on gear design. It should form, however, a sound foundation upon which logical design practices and design data can be erected."

Professor Buckingham has succeeded. He can be proud of his book because it provides both the complete mathematical analysis and the foundation for design. So would a fine treatise on aerodynamics provide a basis for airplane design.

Analytical Mechanics of Gears is an advanced book, undoubtedly the most advanced book on the subject written in any language, yet somehow it manages to state fundamentals and definitions more clearly than the best of the college texts and there are few pages in the book that do not carry significance for the inquiring engineer who is not a gear specialist. Buckingham is of the opinion that full advantage of the properties of the involute gear is not always taken because the method of calculating involute sizes and proportions is not very generally known. The designer who studies carefully Chapters 5 and 6 will certainly acquire such knowledge.

Aeronautical people, who are all concerned with noise, will read the remarks on noise with interest. There is no golden rule for avoiding noise. Accuracy, form, workmanship, housing, backlash, lubrication, all enter into the problem of noise. Aeronautical people will also be interested in the definition of dynamic loads on gear teeth in equations for limiting loads in learning that, after gears reach a pitch-line velocity of the order of 5,000 ft./min., their load-carrying ability is practically constant for any higher speeds. Helicopter engineers will study the pages on efficiencies with eagerness and hope. In some examples, we note efficiencies of 0.99595, power loss of 0.153%. Can such values be possible? Perhaps we can reduce helicopter transmission losses until they are negligible.

Buckingham's *Analytical Mechanics of Gears* is not for beginners, but it will be an intellectual, arduous, valuable treat for the specialist, and an invaluable source of reference for every aviation man seriously concerned with gears and gearing.

DR. ALEXANDER KLEMIN
Consulting Engineer

Book Notes

ATOMIC ENERGY

The Atomic Age. (The Sir Halley Stewart Lectures, 1948.) London, George Allen and Unwin, Ltd.; New York, The Macmillan Company, 1949. 149 pp. $2.50.

Contents: The Scientific Achievement, by M. L. Oliphant; Military Consequences of Atomic Energy, by P. M. S. Blackett; The Economic Consequences of Atomic Energy, by R. F. Harrod; Values in the Atomic Age, by Bertrand Russell; The Political Repercussions of Atomic Power, by Lionel Curtis; America as Atlas, by D. W. Brogan.

Atomic Energy Year Book. Edited by John Tutin. London, Temple Press, Ltd.; New York, Prentice-Hall, Inc., 1949. 237 pp. illus., $3.85.

The editor's purpose is to review past developments in atomic energy and summarize current nonsecret lines of research and their expected outcome. Technical facts are supplemented by a great deal of directory information and data on the progress made in specific laboratories and specific countries. The economic and legal aspects of atomic energy development are covered also, and the medical aspects are more thoroughly covered than any other application. A chapter on the design of laboratories, a list of national scientific academies, and a bibliography of book and periodical titles are included.

ELECTRONICS

Post War Communications Receiver Manual, Including Aircraft and Marine Radio. 2nd edition. Indianapolis, Howard W. Sams & Company, Inc., 1948. 226 pp., illus., diagrs. $3.00.

About 30 receivers by Collins, Gon-Set, Hallicrafters, Hammarlund, National and RME, and 23 aircraft and marine radios by Airadio, Hallicrafters, Harvey Wells, Heath, Jefferson Travis, Learadio, Motorola, and Ranger are illustrated and described. The descriptions are standardized, including keyed illustrations inside and out, parts lists, and schematic diagrams. Part numbers of standard brand products for replacements are included.

For information on I.A.S. Library Service Facilities, see page 41

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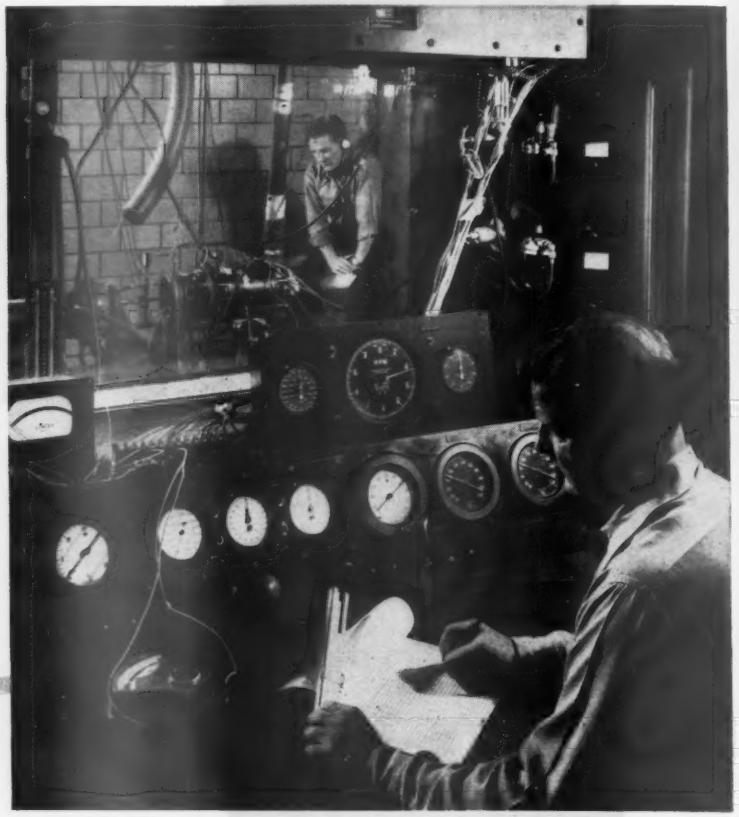

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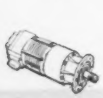
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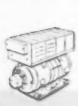
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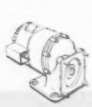
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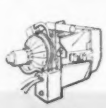
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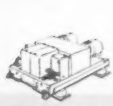
ELECTRICAL SYSTEMS AND CONTROLS

HISTORY

History of the Tools Division, War Production Board. Bradley Stoughton. New York, McGraw-Hill Book Company Inc., 1949. 154 pp., illus., diagrs. $10.

The machine tool industry began cooperation with the Navy and War Departments as early as 1936, and a civilian organization for the stimulation of production and the solution of production problems was established in 1940 in Washington. This became the Tools Division of the War Production Board, which at its peak in 1943 employed between 200 and 300 technicians and 700 to 800 in its clerical staff. This history covers highlights in the story of the Division, with emphasis upon the people who served in it. A list of the men, with their positions previous to connection with the Division, present positions and address, and a list of other personnel, who served one and one-half years or more, are included.

MACHINE ELEMENTS

Bevel Gears (Machine Cut). (British Standard B.S. 545: 1949.) London, British Standards Institution, 1949. 37 pp., diagrs. 7s.6d.

This standard, first issued in 1934, applies to machine cut conical gears designed for peripheral speeds of 2,000, 3,000, and 1,200 ft. per min. Definitions, forms of gear tooth, permissible errors and tolerances, determination of load capacity, and limiting working temperature are discussed. Charts to aid in calculations are included in appendixes.

MATERIALS

Titanium, Its Occurrence, Chemistry and Technology. Jelks Barksdale. New York, The Ronald Press Company, 1949. 591 pp., illus. $10.

The author's aim is to fill the need for a systematic survey of existing information on titanium and its alloys, covering all aspects of the subject. The occurrence, production, and imports of titanium are covered in the first three chapters. The chemistry is covered in the next four chapters leading into the technology and use of titanium for pigments, covered in eleven chapters. The final eight chapters deal with ferrous and nonferrous alloys of titanium, ceramics, mordants and dyes, hard alloys, catalysis, and special applications. More than 2,200 references are cited to published articles and patents on all phases of the subject except the analytical chemistry of titantium, covered by earlier work. Analytical chemistry is covered generally, and other phases exhaustively. The author is with the faculty of the Alabama Polytechnic Institute, and was formerly a research chemist with the Titanium Division of the National Lead Company.

PRODUCTION

Carbide Cutting Tools; How to Make and Use Them. Warren Baker and Joseph S. Kozacka. Chicago, American Technical Society, 1949. 416 pp., illus., diagrs. $5.50.

This book is designed primarily for the vocational student, the machine operator, and the tool buyer, and is a ready source of information for the tool engineer and designer. The design, manufacture, use, and maintenance of carbide forming and cutting tools are discussed, including the conversion of older machines, comparison with high-speed tools, and the names and characteristics of the different grades of carbide. The book is profusely illustrated, and contains considerable information in table form. References to trade catalogs and periodicals are included at the ends of chapters.

Techniques in Plant Layout. James M. Apple. Revised edition. East Lansing, Mich., Michigan State College Press, 1949. 66 pp., diagrs. $1.85.

This textbook was first published in 1948. The introductory chapters outline the overall objectives and the functions of the plant layout group, and go into considerable detail on the factors to consider as a first step in planning a plant layout. Further steps are then outlined, including discussions of flow of materials, materials handling, and

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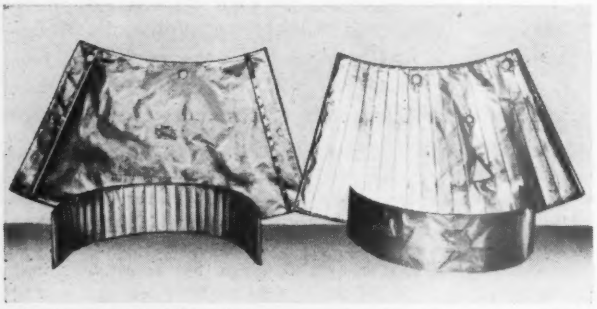

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ROTATING WING AIRCRAFT (34)

American Helicopter Society. Proceedings of the Fourth Annual Forum, Philadelphia, April 22-24, 1948. Bridgeport, Conn., The Society, 1949. Various paging. $6.00.

Table of contents: Co-Axial Design for Helicopter Mass Production, by Rowland J. Watson, 7 pp. Contribution to the Problem of Helicopter, Discourse for the Helicopter Design Session at the 4th Annual Forum of the American Helicopter Society, April 22, 1948, by Kurt Hohenemser, 5 pp. Contribution to the Problem of Helicopter Stability, by Kurt Hohenemser, 18 pp. Gyroscopic Forces on Hinged Rotors, Discourse for the Helicopter Design Session at the 4th Annual Forum of the American Helicopter Society, by Garry C. Myers, Jr. April 22, 1948, 9 pp. Notes on the Flying Qualities of Helicopters, by John P. Reeder, F. B. Reeder, and F. B. Gustafson, 10 pp. Some Aspects of Convertible Aircraft Design, by R. L. Lichten, 23 pp. Lubrication Considerations in Helicopter Transmissions, by Robert A. Wolf and Arthur N. Lappin, 22 pp. The Design of Rotor Blade Dampers, by L. L. Douglas, 12 pp. Attacking the Maintenance Problem Through Mechanical Design, by Glidden S. Doman, 4 pp. The Coast Guard Cutter-Helicopter Team, by Commander F. A. Erickson, 4 pp. Commercial Helicopter Operations, by Knute Flint, 15 pp. Economic Factors Relating to Helicopter Air Mail Operations, by Jack E. Rothman, 16 pp. Application of the Helicopter in Connection with Surface Transport, by Russell B. James, 5 pp. A Review of the Motion Picture "Los Angeles Airways Operations," by V. R. Short, 2 pp. Helicopters Stabilizing Device, by R. Dorand, 21 pp. The Gyrodyne, by Dr. J. A. J. Bennett, 8 pp. Helicopter Development at Bristol Aircraft, by Raoul Hafner, 7 pp. The Helicopter in the Post Office Department, by Paul Aiken, 4 pp. The Military Aspects of Rotary Wing Development, by A. T. Culbertson, 3 pp. Army Air Rescue Operations, by James Lyons, 3 pp.

SCIENCES, GENERAL

MATHEMATICS

Advanced Calculus for Engineers. F. B. Hildebrand. New York, Prentice-Hall, Inc., 1949. 594 pp., diagrs. $8.00.

The author's purpose is to present a textbook covering topics based upon a foundation of elementary calculus, which are of common importance in a number of fields of application. The first five chapters deal chiefly with ordinary differential equations, including a review of fundamental solutions in the first chapter, the Laplace transformation, numerical methods of solution, series solution, boundary-value problems, and orthogonal functions. Vector analysis, including its application to fluid flow problems, is next discussed, followed by two chapters on partial differential equations, including their applications in mathematical physics. The final chapter is on functions of a complex variable. References to books are included at the ends of chapters. The author is Assistant Professor of Mathematics at the Massachusetts Institute of Technology.

Fourier Transforms. S. Bochner and K. Chandrasakharan. Princeton, N. J., Princeton University Press, 1949. 219 pp. $3.50.

Fourier Transforms and topics naturally connected with them are presented in the form of some 95 theorems, with proofs, examples, and accompanying remarks. The first two chapters deal with Fourier Transforms in L_1, with one variable and with several variables. The third covers Lp-Spaces, and the last half of the book covers Fourier Transforms in L_2, General Transforms in L_2, and General Tauberian Theorems.

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The Real Projective Plane. H. S. M. Coxeter. New York, McGraw-Hill Book Company, Inc., 1949. 196 pp., diagrs. $3.00.

Designed as an introductory textbook for a college course in projective geometry, this volume covers the real geometry of two dimensions with a mainly synthetic treatment, introducing analytic geometry only in the two final chapters on coordinates. The continuity of the projective line is introduced in Chapter 3 and is more fully discussed in Chapter 10 by means of an improved and greatly simplified axiom. The synthetic approach of von Staudt to collineations, polarities, and conics, published in the middle of the 19th century and amplified in 1904 by the Italian mathematician Enriques, is given its first systematic exposition in English in Chapters 5 and 6. A bibliography of 45 titles is included. The author is a Professor of Mathematics at the University of Toronto.

Differential Equations. 2nd edition. Harry W. Reddick. New York, John Wiley & Sons, Inc., 1949. 288 pp., diagrs. $3.00.

In this new edition of a textbook first published in 1943, a new chapter has been added on the linear equation of the second order, and new material on hyperbolic functions, systems of curves, and vibratory motion. The number of problems has been increased, and answers are given to all. Professor Reddick is with New York University.

Mathematics for Industry. S. E. Rusinoff. Chicago, American Technical Society, 1949. 519 pp., diagrs. $5.50.

The author's purpose is to present in simplified form the mathematics most often used in practical engineering, machine shop practice, and the drafting room, including arithmetic, algebra, geometry, trigonometry, logarithms, and the slide rule. Applications to screw threads and gears are discussed in separate chapters, and a final chapter deals with computations in applied mechanics. Tables are included in an appendix. The author is Assistant Professor of Mechanical Engineering at the Illinois Institute of Technology. Answers to problems are included in a separate pamphlet of 30 pages.

MECHANICS

Mechanics: Statics and Dynamics. Merit Scott. New York, McGraw-Hill Book Company, Inc., 1949. 394 pp., diagrs. $4.50.

The purpose of this textbook is to prepare students who have completed elementary mechanics courses for studies requiring higher mathematics. Besides the fundamentals of mechanics, the reader requires a knowledge of vector notation and analysis (included in the opening chapters), the calculus, series expansions, Taylor's theorem, and some analytical geometry. The problems are considered integral parts of the subjects discussed and must be used with the text and illustrative examples for complete understanding of the discussion. The author is a Professor of Physics at The Pennsylvania State College.

STRUCTURES

Strength of Materials. Gerner A. Olsen. New York, Prentice-Hall, Inc., 1949. 442 pp., diagrs. $5.70.

This textbook is designed for use in schools, colleges, and extension courses, teaching strength of materials where the calculus is not a required subject. Chapters 1 and 2 review statics, center of gravity, and moment of inertia, and Chapter 3 takes up fundamental stress and strain relationships. Stresses in thin-walled cylinders and spheres, riveted and welded joints, torsion, and shear and bending moment diagrams conclude the first half of the book. Beam design, beam deflection, statically indeterminate beams, stresses due to eccentrically applied loads, columns, combined stresses, and stress concentrations in relation to fatigue strength are discussed in the last half. The author is a Professor of Civil Engineering at the College of the City of New York.

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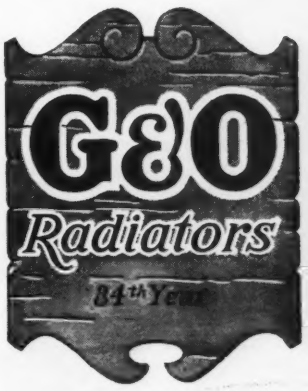

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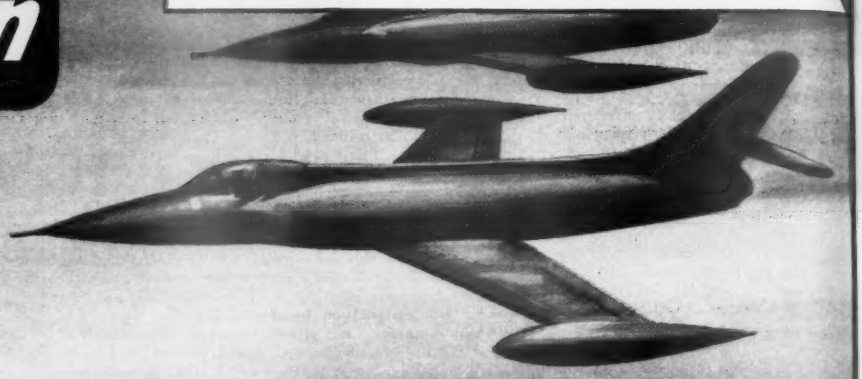

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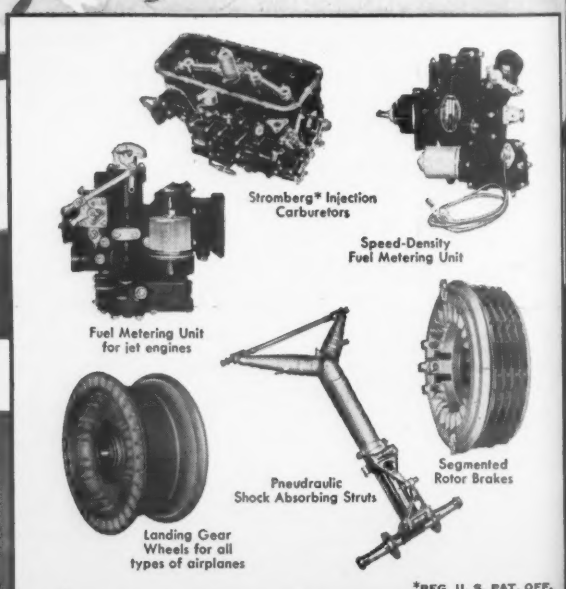
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Causey, Andrew J., Jr., B.S. in M.E. (Aero.), Lt. (j.g.), U.S.N.R.; Aero. Engineer P-1, Dynamics Branch, Air Materiel Command, Wright-Patterson A. F. B.

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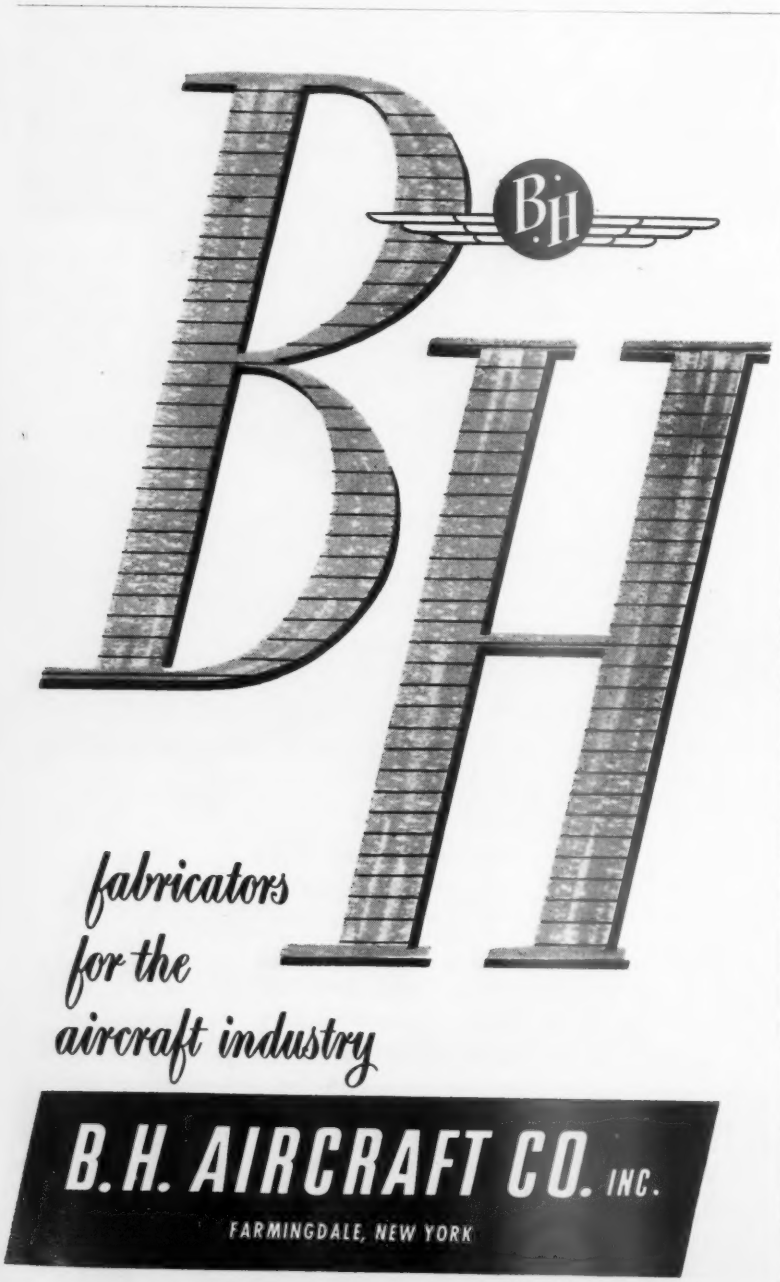
Hanson, Thomas F., B.S. in Ae.E., Jr. Engineer, Boeing Airplane Co. (Seattle).



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Kelman, Edward J., Engineer, Grade IV, Design Draftsman, A. V. Roe Canada, Ltd. (Malton).

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Lewis, Barney L., B.S., Draftsman "B," Hydraulics Group, Consolidated Vultee Aircraft Corp. (Ft. Worth).

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Lucas, John H., B.A.Sc., Design Draftsman, A. V. Roe Canada, Ltd. (Toronto).

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Shohet, Herbert N., B.Sc. in Ae.E., Production Liaison Engineer, Chance Vought Aircraft Div., United Aircraft Corp.

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Sloat, Robert D., B.A.Sc., Flight Lt. and Aero. Engineer, Royal Canadian Air Force (Trenton, Ont.).

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Statham, Stanley U., Draftsman "B," Lockheed Aircraft Corp.

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Stoney, William E., Jr., S.B. in Ae.E., Engineer P-1, N.A.C.A., Langley Air Force Base.

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Terry, John W., A.A. in Ae.E., Technical Asst., Flight Test Section, Chance Vought Aircraft Div., United Aircraft Corp.

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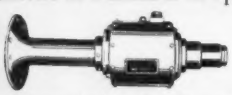

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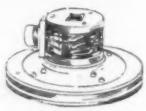

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Research Engineers—To perform studies on combustion problems; aid in development testing of ram-jet engines. Applicant must have experience in some phase of combustion as applied to ram-jet, turbojet, or pulse-jet engines. Ability to write acceptable reports considered important. **Aerodynamics Engineer**—With advanced degree to perform studies in aerodynamics and thermodynamics. Knowledge of supersonic aerodynamics required. Must have some knowledge of jet-power-plant field, preferably with ram-jet engines. Positions available with progressive young company on West Coast for qualified persons. Salary dependent upon qualifications. Marquardt Aircraft Company, 7801 Hayvenhurst Ave., Van Nuys, Calif.

Engineers—The following vacancies exist at the recently established Naval Aeronautical Rocket Laboratory: Aeronautical Engineers—P-1 through P-6, $2,974.80 through $7,432.20. Electronics Engineers—P-2 through P-4, $3,727.20 through $5,232. Chemists—P-3 through P-5, $4,479.60 through $6,235.20. Chemical Engineers—P-3, $4,479.60. Physicist—P-4, $5,232. Assignments include testing, evaluation, research, and development of liquid-propellant rocket engines. Applicants must have experience and/or training in the construction, operation, and performance of rocket engines. Both staff and project engineer positions are open. Address replies, enclosing completed copy of Civil Service Application Form 57 (obtainable at your Local Post Office), to Donald K. Holster, Personnel Officer, U.S. Naval Aeronautical Rocket Laboratory, Lake Denmark, Dover, N. J.

College Instructor—Aeronautical Design Engineer wanted to teach College undergraduate courses in aircraft drafting and design and allied courses. Several years of industrial experience required. Advanced degrees not necessary. Salary and rank dependent upon qualifications. Address: Aeronautical Department Head, California State Polytechnic College, San Luis Obispo, Calif.

70. Director of Engineering—To head engineering and research department of leading manufacturer of aircraft and industrial electromechanical equipment. Must have proved record of experience and ability in this specialized field, particularly with regard to mechanical design. Substantial salary, plus royalty on new designs. Forward complete résumé in applying.

37. Development Engineer—To make studies of highly technical products and manufacturing operations on a consulting basis. Excellent opportunities for capable engineer experienced in design and development of precision metal equipment. Should possess M.E.—Aero. or Physics degree; graduate work preferred. Require 3 to 5 years' industrial experience and a sound knowledge of production and administrative problems.

30. Aircraft Division Manager—To take charge of Engineering and Sales with a manufacturer of aviation equipment. Must be thoroughly experienced in design and performance of military aircraft and must have wide knowledge of the aircraft industry, as well as the armed forces. Only men with a proved record in the design and marketing of aircraft equipment will be considered.

29. Flight Test Instrumentation Engineer—To prepare instrumentation programs, guide procurement, design special equipment, supervise installation and maintenance of testing equipment of experimental aircraft. Broad experience including mechanical, electric, electronic, and photographic data recording desired. Inquiry should include education and experience summary. Location—Southern California.

28. Flight Test Engineer—To prepare general Testing programs, detailed test outlines, and summary reports and to coordinate all aspects of flight-test programs on experimental aircraft. Will fly as observer during engineering testing. Experience with both Air Force and C.A.A. testing desirable. Inquiry should include education and experience summary. Location—Southern California.

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The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

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69. Washington Representative—Aeronautical Engineer, M.S., Ae.E., California Institute of Technology; 18 years' experience in the Naval Aeronautical Organization. Technical operation and administrative, including 2½ years in the Bureau of Aeronautics and over 3 years in the Office of Chief of Naval Operations. Familiar with Government contract procedures, specifications, and requirements. Retired in 1947, with senior naval rank, at age of 45, and living in Washington, D.C., area. Has office to handle Washington representation for reliable company in the aviation industry.

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67. Management Staff—Aeronautical engineer, graduate of M.I.T., with broad experience in engineering and sales management in aircraft components field. Has held position of project engineer, administrative engineer, and assistant sales manager. Familiar with production, contracting, and accounting control problems. Has excellent contacts among industry and with Government groups. Age 34; married. Location open.

66. Engineer — Executive — Pilot — Former Chief Engineer, world's largest manufacturer of propellers for personal aircraft. Extensive experience in propeller and fan development on wood and metal, fixed- and variable-pitch propellers and wind-tunnel fans. Broad acquaintances in personal aircraft industry. Flight-test experience on a wide variety of aircraft in functional and performance testing. Patent experience. Commercial Pilot. Unmarried and able to travel anywhere. Age 32.

65. Aircraft Propulsion Engineer—Graduate in Mechanical Engineering from a University in India, with the Postgraduate Diploma of the Indian Institute of Science in Aeronautical Engineering and the Postgraduate Diploma of the Imperial College of Science and Technology, London, England. Desires a position with an air line or an aero-engine manufacturer as a testing or field service engineer or in any other suitable technical capacity. Has the following experience and background to offer: More than 2 years of general engineering and business experience, including responsible positions. In addition, 1 year of experience in India and England in aeronautics as an employee of a Czechoslovakian engine manufacturer in Prague. Fluent command of the Czech language and an elementary knowledge of Spanish. Extensive top-level contacts in Indian and Czech civil aviation and industry. Age 26; bachelor; willing to work on contract or permanent basis. Interesting work the main consideration. Further particulars and references on request.

64. Aeronautical Engineer—Stress Analyst—M.Sc. (Math.), B.Sc. (Physics, Chem., Math.). Four years' teaching experience. Devoted 8

years to design, development, and research work on aero engines and propellers. Some experience in aircraft work. Desires position that requires design and/or research on problems in structures, aero engines, or allied mathematical subjects, including statistics either in aircraft industry or an aeronautical institution. Age 37. Resident in England and English citizen.

63. Aerodynamicist—B.S. Some graduate work. Age 27. Stability and control, wind-tunnel work, special devices. Five years' experience in aircraft industry.

62. Aviation Maintenance Engineer—B.S. Aero. Eng. C.A.A. aircraft and engine mechanic, restricted radio operators permit. Three years' experience in the business and maintenance of various transports. Desires position that will use abilities with air line, operator, feed line, maintenance shop, etc. Age 23; married; available immediately.

61. Aeronautical Engineer—1949 graduate. Five years' experience in airplane and engine maintenance, manufacturing, and modification. Underwent pilot training in Army. Age 25, ambitious, desires permanent position with opportunity for advancement in Production Manager's Department of aviation or related industry. Available immediately.

60. Engineering Pilot—B.S. Aero. E., University of Michigan. Age 31; married. Fourteen years' flying experience. Pilot—commercial airplane single- and multiengined land, with instrument and flight instructor ratings; 2,600 hours' total flying time, 1,700 multiengined. Three and one-half years' flight-test experience with West Coast manufacturer as engineering test pilot. Has thorough engineering and flight background in aircraft performance, stability, and controllability, with broad experience in aircraft engine design and performance. Three and one-half years with air lines as air-line pilot, engineering and maintenance test pilot, and consulting engineering pilot. Experienced in domestic and overseas air-line piloting. Has thorough working background in flight analysis work with emphasis on aircraft performance as applied to the C.A.A. requirements for Air Transport Category, including considerable experience in airport analysis work. Has engaged in, and been in charge of, development of Pilots Aircraft Operating Manuals for aircraft manufacturer and air lines, and development of flight-test procedure manuals for air-line test pilots. Interested in engineering and piloting position with air line or manufacturer offering possibilities of good future.

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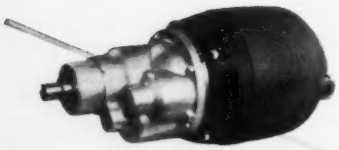

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56. Aeronautical Engineer—Design, Stress, or Research.—Doctor's Degree. Ten years' industrial experience in responsible design and research capacity. Presently head of aeronautical option with eastern college. Would consider with interest an outside position for a design, research, and/or development assignment in structures or general air-frame design field. Could dedicate up to 200 engineering man-hours per week by utilizing other faculty members with equivalent industrial experience.

55. Associate Professor—Aeronautical or Mechanical Department. Doctor's Degree. Ten years' industrial experience in supervisory design capacity. Teaching experience in stress analysis, aircraft structures, theory of machines, thermodynamics, fluid mechanics, etc. Wants similar position with university in New York Metropolitan Area or vicinity.

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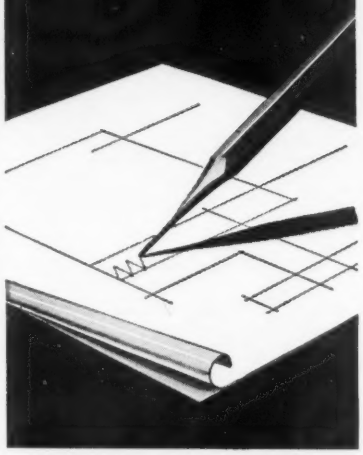

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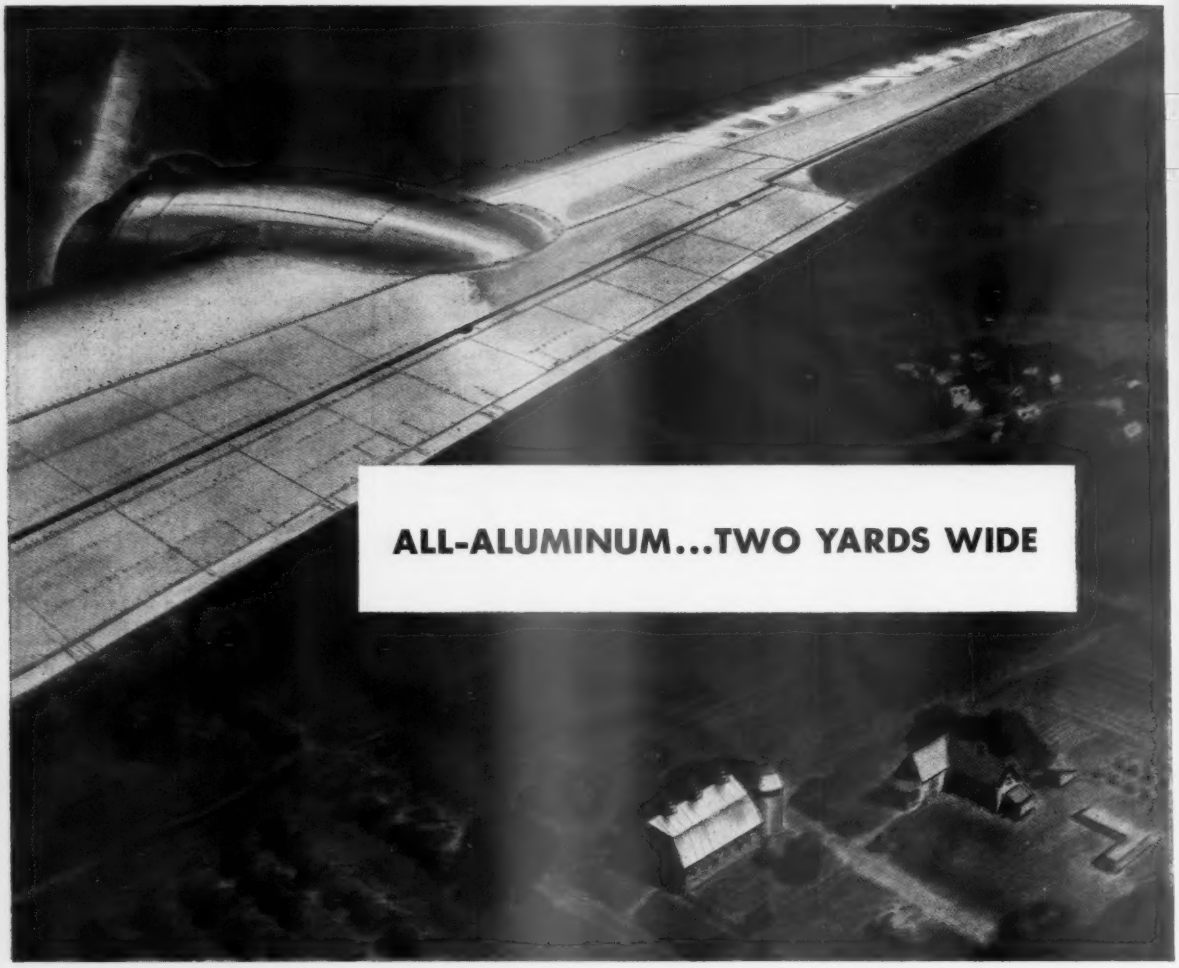

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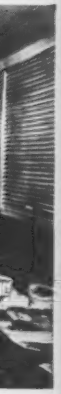

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